JOURNAL OF THE

SMPTE

485 A Standard for Positioning the Vacuum Guide in Transverse Track Video-Tape Recorders • *A. H. Lind*

489 Time-Base Errors and Their Correction in Magnetic Television Recorders • *Aubrey Harris*

494 Cablefilm Equipment • *C. B. B. Wood, S. H. Padel and Peter Rainger*

498 A Damping Device to Improve the Image Sharpness and Steadiness of Prints Made on a Continuous 16mm Motion-Picture Printer • *Gerald M. Seeley*

500 A Constant-Time, Variable-Intensity Microsecond Exposure Sensitometer • *Frank P. Herrnfeld*

502 Establishing and Maintaining Printer Light Color Balance in Additive Color Printing by a System of Controlled Chance • *Pablo Tabernero*

509 Some Uses of Optical Masers in Photography • *J. S. Courtney-Pratt*

512 Applications of the Type C5 Rotating Mirror Framing Camera • *K. R. Coleman and A. Skinner*

515 What Is the Sensitivity of a Photographic System? • *Fred H. Perrin*

522 A Kerr-Cell Camera With Synchronized Light Source for Millimicrosecond Reflected Light Photography • *George A. Theophanis*

527 Electronic Image Intensification: Image Intensifier Using Cathodo-Conductivity • *R. A. Chippendale and J. R. Folkes*

533 Recommended Practices and Standards:

Recommended Practice RP 8, Safe Title Area for TV Transmission

Proposed American Standards: PH22.37, Dimensions for Raw Stock Cores for 35mm Motion-Picture Film; PH22.127, Magnetic Coating of 16mm Magnetic-Photographic Sound Record

American Standards: PH22.3, 35mm Photographic Sound Motion-Picture Film Usage in Projector; PH22.43, 16mm 3000-Cycle Flutter Test Film, Photographic Type; PH22.51, Intermodulation Tests for 16mm Variable Density Photographic Sound Prints; PH22.56, Nomenclature for Motion-Picture Film Used in Studios and Processing Laboratories (Section 1-4)

542 Toronto Convention Report

90th SMPTE Convention • October 1–6 • Lake Placid Club, Essex County, N. Y.

volume 70 • number 7 **JULY 1961**

JOURNAL of the SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

PUBLICATION OFFICE TWENTIETH AND NORTHAMPTON STREETS EASTON, PA.

Officers

President, 1961–62
JOHN W. SERVIES, National Theatre Supply Co., 50 Prospect Ave., Tarrytown, N.Y.

Executive Vice-President, 1961–62
REID H. RAY, Reid H. Ray Film Industries, 2269 Ford Parkway, St. Paul 16, Minn.

Past-President, 1961–62
NORWOOD L. SIMMONS, Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38, Calif.

Engineering Vice-President, 1960–61
DEANE R. WHITE, Photo Products Dept., E. I. du Pont de Nemours & Co., Inc., Parlin, N.J.

Editorial Vice-President, 1961
GLENN E. MATTHEWS, Research Labs., Bldg. 59, Kodak Park, Eastman Kodak Co., Rochester 4, N.Y.

Financial Vice-President, 1960–61
ETHAN M. STIFLE, Eastman Kodak Co., 342 Madison Ave., New York 17, N.Y.

Convention Vice-President, 1961–62
HARRY TEITELBAUM, Hollywood Film Co., 956 Seward St., Hollywood 38, Calif.

Sections Vice-President, 1960–61
GARLAND C. MISENER, Capital Film Laboratories, 1905 Fairview Ave., N.E., Washington, D.C.

Secretary, 1961–62
HERBERT E. FARMER, 7826 Dumbarton Ave., Los Angeles 45, Calif.

Treasurer, 1960–61
G. CARLETON HUNT, General Film Laboratories, 1546 N. Argyle Ave., Hollywood 28, Calif.

Governors, 1960–61
MAX BEARD, 10703 East Nolcrest Dr., Silver Spring, Md.
EDWARD H. REICHARD, 13059 Dickens St., North Hollywood, Calif.
MALCOLM G. TOWNSLEY, Bell & Howell Co., 7100 McCormick Rd., Chicago 45, Ill.
W. W. WETZEL, 725 Ridge St., St. Paul, Minn.
CHARLES W. WYCKOFF, 69 Valley Rd., Needham 92, Mass.

Governors, 1961–62
JAMES W. BOSTWICK, General Motors, 465 W. Milwaukee, Detroit 2, Mich.
G. R. CRANE, 212 24th St., Santa Monica, Calif.
ROBERT G. HUFFORD, Eastman Kodak Co., 6706 Santa Monica Blvd., Hollywood 38, Calif.
WALTER L KISNER, 123 Browncroft Blvd., Rochester 9, N.Y.
KENNETH M. MASON, Eastman Kodak Co., Prudential Bldg., Room 2006, Chicago 1
RODGER J. ROSS, 784 Dutchess Dr., Applewood Acres, Port Credit, Ont., Canada

Governors and Section Chairmen, 1961
WILLIAM H. METZGER, Ansco, 405 Lexington Ave., New York 17
RALPH E. LOVELL, 2554 Prosser Ave., Los Angeles 64, Calif.

Section Chairmen
DONALD E. ANDERSON, 1718 Valley View Ave., Belmont, Calif.
ROBERT M. FRASER, Information Technology Laboratories, 10 Maguire Rd., Lexington 73, Mass.
ERIC C. JOHNSON, 139 Tobey Rd., Pittsford, N.Y.
MALCOLM D. McCARTY, 440 Wildwood Rd., Dallas, Texas
FRANK M. McGEARY, M-P Laboratories, 781 South Main St., Memphis 6, Tenn.
FINDLAY J. QUINN, TransWorld Film Laboratories Ltd., 4824 Cote des Neiges Rd., Montreal, Que., Canada
WESLEY R. SANDELL, Kodak Processing Lab., 4729 Miller Dr., Chamblee, Ga.
WILLIAM H. SMITH, 9930 Greenfield Rd., Detroit 27, Mich.
WILLIAM E. YOUNGS, 231 Mayflower Dr., McLean, Va.

Editorial Office

55 West 42 St., New York 36, New York

Editor—VICTOR H. ALLEN
Advertising Manager—DENIS A. COURTNEY

BOARD OF EDITORS

Chairman—PIERRE MERTZ
66 Leamington St., Lido, Long Beach, N.Y.

HARLAN L. BAUMBACH	CLYDE R. KEITH
MAX BEARD	W. L KISNER
GERALD M. BEST	RALPH E. LOVELL
GEORGE R. CRANE	HERBERT W. PANGBORN
HAROLD E. EDGERTON	BERNARD D. PLAKUN
CARLOS H. ELMER	WALDEMAR J. POCH
CHARLES R. FORDYCE	ALLAN L. SOREM
LLOYD T. GOLDSMITH	R. T. VAN NIMAN
LORIN D. GRIGNON	DEANE R. WHITE
A. M. GUNDELFINGER	W. T. WINTRINGHAM
CHARLES W. HANDLEY	HAROLD WRIGHT
RUSSELL C. HOLSLAG	CHARLES W. WYCKOFF

EMERSON YORKE

Papers Committee Chairman—ROBERT C. RHEINECK
CBS News, 485 Madison Ave., New York 22, N.Y.

Subscriptions to nonmembers, $12.50 a year (outside continental United States, add $1.00 for postage); subscribers residing in countries which participate in UNESCO may use UNESCO coupons in submitting subscription payments in the event other means of remitting are not available; single copies, $2.00 for one-part issues, $2.50 for special two-part issues. A 10% discount is allowed to individual members and accredited agencies on orders for subscriptions and single copies. A list of priced and gratis publications is available. Order from the Society's Headquarters Office, 55 West 42d St., New York 36.

THE SOCIETY is the growth of over forty years of achievement and leadership. Its members are engineers and technicians skilled in every branch of motion-picture film production and use, in television, and in the many related arts and sciences. Through the Society they are able to contribute effectively to the technical advance of their industry. The Society was founded in 1916 as the Society of Motion Picture Engineers and was renamed in 1950.

Membership in Sustaining, Active, Associate or Student grades is open to any interested person according to his qualifications. Information about membership, technical activities and standards and test films for the industry is available from Society Headquarters. Members residing in countries which participate in UNESCO may use UNESCO coupons in submitting membership payment in the event other means of remitting are not available.

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

Headquarters Office: 55 West 42d St., New York 36, N.Y. Cables: Somopict Telephone: LOngacre 5-0172

Executive Secretary: CHARLES S. STODTER

Published monthly by the Society of Motion Picture and Television Engineers. Publication office 20th and Northampton Sts., Easton, Pa. Second-class mail privileges authorized at Easton, Pa. This publication is authorized to be mailed at the special rates of postage prescribed by Section 132.122.

Copyright 1961, by the Society of Motion Picture and Television Engineers, Inc. Permission to republish Journal text material must be obtained in writing from the Society's Headquarters Office, 55 West 42nd St., New York 36. The Society is not responsible for statements of contributors.

Printed by Mack Printing Company, Easton, Pa.

Journal of the Society of Motion Picture and Television Engineers

VOLUME 70 • NUMBER 7 • JULY 1961

A Standard for Positioning the Vacuum Guide in Transverse Track Video-Tape Recorders

By A. H. LIND

The SMPTE Video-Tape Recording Committee has developed a Recommended Practice for transverse track video-tape recording which results in a constant recorded video-track length per TV line period. Adherence to this Recommended Practice will improve the interchangeability and interspliceability of recorded tapes. The Recommended Practice establishes the proper position of the vacuum guide with respect to the axis of rotation of the video heads as a function of the vacuum guide radius. The background for this Recommended Practice is outlined and the relationships that are specified in it are explained.

RECORDED TAPE interchangeability and interspliceability were prime objectives in the development of the Recommended Practice *Tape Vacuum Guide Radius and Position for Recording Standard Video Records on 2-Inch Magnetic Tape* by the SMPTE Video Tape Recording Committee. Attention was also directed at the need to obtain maximum video-head life consistent with meeting these prime objectives. Further, it should be noted that vacuum guide radius and position are only two of a number of factors that must be accommodated in the achievement of recorded tape interchangeability and interspliceability.*

When signals are being recorded on or reproduced from a previously recorded magnetic tape in the transverse track system of video recording, the magnetic tape is shaped into a complex three dimensional surface. This is illustrated pictorially in Fig. 1. The tape is subjected to longitudinal tension by the combined action of the supply reel holdback torque, frictional drag at points of rubbing contact, tape speed regulating torque of the capstan and the take-up reel torque. Second, the tape is cupped by means of a vacuum guide so that the cross section of the tape at the plane of the rotating video magnetic heads is curved to form a sector of a circle. Third, the pole tips of the rotating heads cause localized stretching of the tape by deflecting it into a cavity in the vacuum guide. In addition, it should be recognized that the physical dimensions of the tape are subject to a small but not a negligible change as a function of temperature and humidity.

To better understand the physical process of recording, consider the diagram of Fig. 2. The tape, as inserted in the recorder, will have a given width at the ambient temperature and humidity. The tape will be shaped into the curved profile shown by the vacuum hold-down action of the vacuum guide. The guide is then positioned so that the oxide surface is deflected into the vacuum guide tape cavity by the video-head pole tips as shown in the enlarged cross section view. (R_g is the radius of curvature of the vacuum guide surface, R_w is the radius of the headwheel, R_t is the radius of rotation of the magnetic pole tips and T is the thickness of the tape.)

The purpose of the localized stretching or apparent "penetration" of the nominal oxide surface is twofold. First, the head-to-tape force generated by the stretching insures sufficiently intimate contact between the pole tips and oxide coating to achieve good signal transfer to the oxide. Second, a compensating effect to accommodate the wearing away of the pole-tip material by the mutual abrasion of the oxide coating and the pole tips is achieved. Assume for the present that the axis of rotation of the heads and the center of curvature of the vacuum guide are coincident, i.e. $E = 0$. When the tape is stretched by pole-tip penetration, empirical data lead to the conclusion that a given oxide particle moves in a radial direction away from the center of curvature of the vacuum guide. Thus the track length recorded by a 90° sweep of a video head will shrink back to the length of a 90° sector of the vacuum guide surface. The quiescent recorded track length is thus directly dependent on the radius of the vacuum guide.

Vacuum Guide Positioning

When this recording is played back in the same assembly as recorded it, proper playback will be achieved when the vacuum guide is in the same position as when the tape was recorded. If the tape should be reproduced in the same assembly after substantial wear of pole-tip material has occurred, the vacuum guide position with respect to the axis of rotation of the heads will remain unchanged since 90° of head rotation will still read out the material recorded in 90° of head rotation. Thus the compensating effect for head wear is accomplished.

If, during recording, the vacuum guide is positioned so that its center of curvature differs from the axis of rotation of the heads, the length of video track recorded in 90° of rotation of the heads will shrink back to a guide sector length other than 90°. In a properly set up recorder, the vacuum guide will move in

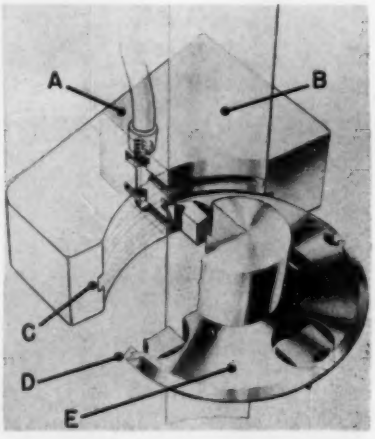


Fig. 1. Shaping of the tape in recording and reproducing. A–tape vacuum guide, B–tape, C–tape and pole tip cavity, D–magnetic head pole tip, E–headwheel.

Presented on May 11, 1961, at the Society's Convention in Toronto, Canada by A. H. Lind, Electronic Recording Products Engineering, Radio Corp. of America, Bldg. 13-4, Camden 2, N.J. (This paper was received on May 11, 1961.)

* K. B. Benson, "Video-tape recording interchangeability requirements," *Jour. SMPTE 69:* 861–867, Dec. 1960.

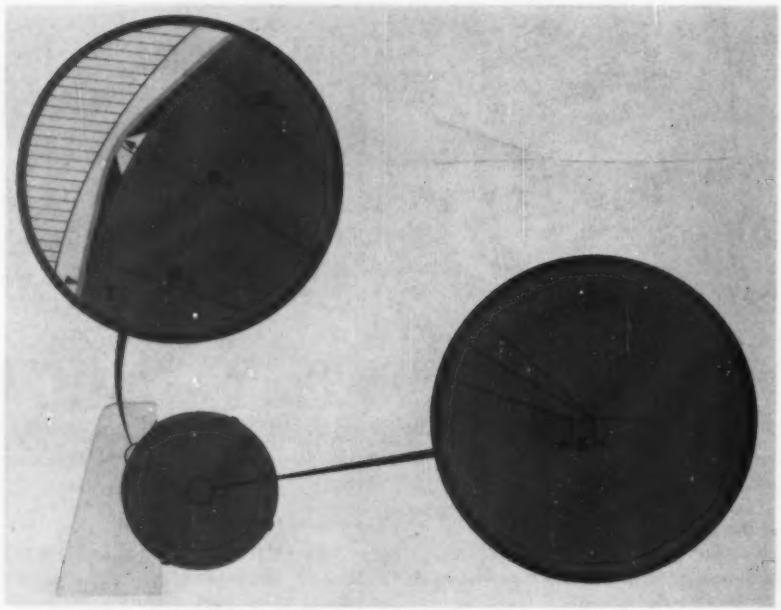
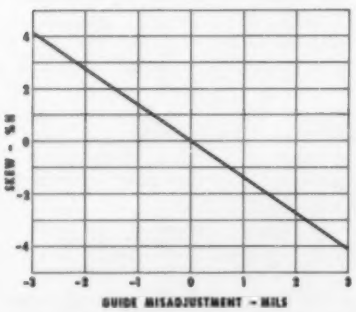


Fig. 2. Head-wheel, tape and vacuum guide relationships.



such a way that its center of curvature will pass along a line which passes through the axis of rotation of the heads and the midpoint of the tape. If the center of curvature is positioned to the left of the headwheel axis, as shown in Fig. 2, the recorded 90° track length will be longer than a 90° sector of the guide surface; and conversely with the center of curvature positioned to the right of the headwheel axis, the recorded 90° track length will be shorter than a 90° sector of the guide surface. Thus a degree of control of the recorded track length is achieved by varying the position or "eccentricity" of the vacuum guide in recording.

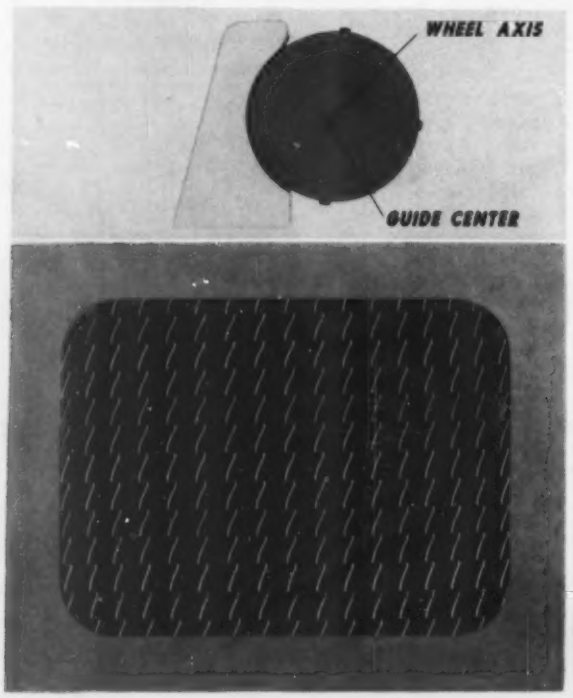


Fig. 3. Skew effect from vacuum guide misadjustment.

Next consider the resulting effect when a vacuum guide is improperly positioned in playback. Figure 3 shows the skew effect when the guide is mispositioned along the reference line which passes through the headwheel axis and the center of the tape. The curve indicates the amount of skew in percent of a TV line period as a function of guide misadjustment. Skew is defined in this case as the separation of the headband segments in time at the junction of adjacent headbands, expressed as a percent of the TV line period. A skew of 0.05% is discernible in the reproduced picture. Thus the positional error must be less than 0.000036 in. (36 μin.) to be undetectable. The kinescope display of a vertical line pattern shows the effect when the vacuum guide is too far away from the headwheel in playback. If the guide is too close, the headband segments of the lines will slope downward to the right instead of the left, as shown. The curve illustrates the sensitivity to vacuum guide positioning that exists in the system.

Figure 4 shows the scallop effect that is present when a vacuum guide is mispositioned in the direction perpendicular to the reference line. Positioning in this direction is also very sensitive. Positional errors of 0.00005 in. (50 μin.) are discernible.

Video Track Length

In order to make recordings that can be spliced together and then played back without skewing or scalloping effects in going from one segment to another, the position of the vacuum guide during the recordings must be precisely controlled. Further, the radius of the vacuum guide is a vital consideration, and the eccentricity of positioning can be used to compensate for differences in this radius. If all recordings are standardized to have a constant video track length per 90° of head rotation, the playback problem is simplified since the position of the guide, once set for proper playback geometry, will remain constant.

The relation between a change in the vacuum guide radius ΔR_g and the necessary change in eccentricity ΔE to maintain a constant video track length per 90° of head rotation is expressed in this simple formula (see Appendix).

$$\Delta E = -1.11\ \Delta R_g$$

Thus, if the radius R_g, as shown in Fig. 2, is increased, the eccentricity E must be decreased to maintain the recorded track length constant. If R_g could be maintained constant in manufacture, this aspect of the problem would be eliminated. However, to be practical in manu-

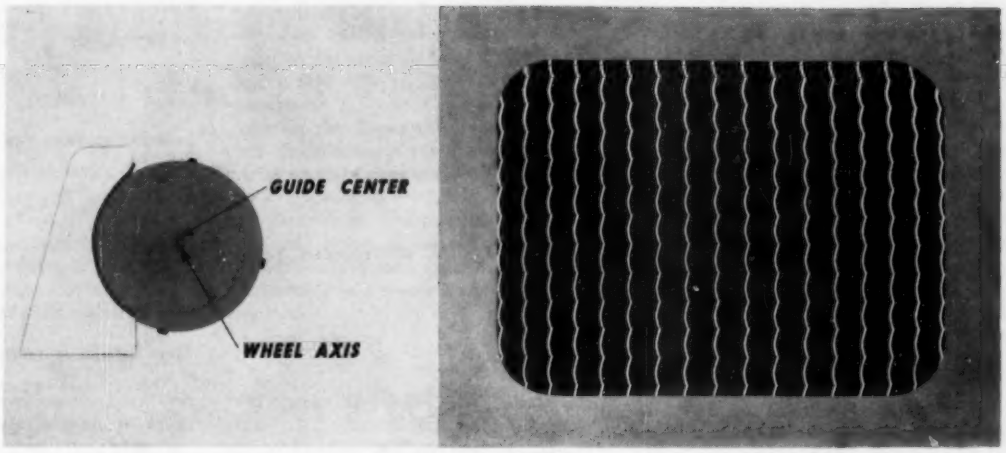


Fig. 4. Scallop effect from vacuum guide misadjustment.

facture, some tolerance on R_g must be allowed. The tolerance presently allowed by both RCA and Ampex is ±0.0002 in. from a nominal dimension of 1.0331 in. Thus the tolerance is ±0.019%. For the SMPTE Recommended Practice, the equation has been simplified to

$$\triangle E = -\triangle R_g$$

The coefficient 1.11 has been rounded off to unity, since carrying the specification to higher accuracy exceeds the present limit of accuracy of measurement of vacuum guide position in the recorder. This simplified equation is the basis for choosing the tabulated vacuum guide radii and corresponding eccentricities in the SMPTE Recommended Practice *Tape Vacuum Guide Radius and Position for Recording Standard Video Records on 2-Inch Magnetic Tape*. These values are shown tabulated in Table I.

Wear Factors

In addition to establishing the means for achieving a constant recorded track length, which compensates for manufacturing tolerances in the radius of the vacuum guide, the actual value of the radius and an absolute value for eccentricity must be established. This choice is based in large part on the consideration of wear of the video magnetic pole tips. It is desirable that the maximum range of wear be accommodated so that tapes recorded with a head assembly on the verge of being worn out can be played back with a new video-head assembly and vice versa. The general requirement which must be met to achieve this condition is that the rim of a maximum diameter headwheel should just touch the oxide surface when the tape is in a maximum diameter vacuum guide. When this is true, the tape can always be played back in another headwheel assembly. Based on this condition, the eccentricity for a 1.0333-in. radius vacuum guide (maximum radius in current manufacture) will be

$$\begin{aligned} E &= R_w - (R_g - T) \\ &= 1.0321 - (1.0333 - .0014) \\ &= 0.0002 \text{ in.} \end{aligned}$$

The choice in the SMPTE Recommended Practice is seen to be 0.0001 in. for this vacuum guide radius. This slight compromise was made to reconcile the standard recording condition to the existing practice of the recorder manufacturers in recording standard alignment tapes.

As was pointed out earlier, when a tape is recorded in a given head assembly and then played back in the same head assembly, the vacuum guide position remains unchanged as the pole-tip material wears away. Under this condition of operation, the wear curve of the video heads of current manufacture is shown in Fig. 5. In this case the initial pole-tip penetration is 3 mils. If tapes that are standard recordings are always played back, the wear of the pole tips will also follow this general curve. The curve has a rather steep slope initially which indicates that the rate of wear increases substantially as the penetration is increased. Figure 6 indicates the wear rate as a function of pole-tip penetration. From this curve it is evident that the wear rate at 3 mils penetration is approximately ten times that at one mil penetration. This curve graphically shows the importance of carefully setting the pole-tip penetration to obtain maximum life.

In order to achieve the intersplice-ability and interchangeability desired, it is necessary to choose recording conditions that will maintain the vacuum guide for a given headwheel assembly in an essentially constant position over the full wear range of the pole tips. This means that a new headwheel assembly

Table I. Vacuum Guide Position for Recording Standard Video Records.

Vacuum-guide radius (in.)	Eccentricity (in.)
1.0334	0.0000
1.0333	0.0001
1.0332	0.0002
1.0331	0.0003
1.0330	0.0004
1.0329	0.0005

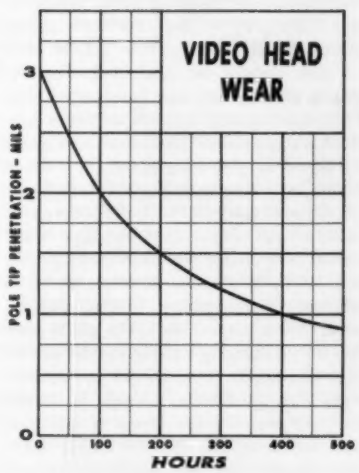


Fig. 5. Video-head wear relationships.

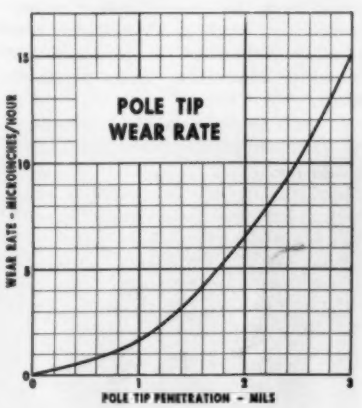


Fig. 6. Pole tip wear rate.

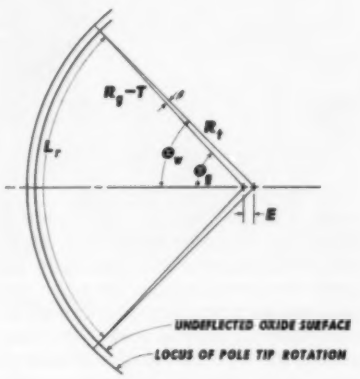
will have to operate with high penetration so that there will be sufficient penetration remaining at the end of its useful life to insure that all properly recorded tapes can be played back. The amount of pole tip material projecting above the rim of the wheel in new headwheel panel assemblies is approximately 3 mils. It is generally possible to wear away all the material that projects above the rim of the wheel; however, it may not be possible to obtain satisfactory performance when the pole-tip penetration becomes less than approximately 0.5 mils.

Temperature and Humidity

The factors of temperature and humidity, as they influence the dimensions of the tape, were mentioned earlier in the paper. Although the coefficients of expansion for temperature and humidity changes appear to be small — Temperature (units/1F) — 2×10^{-6}, Humidity (units/1% RH change) — 1.1×10^{-6} — they cannot be neglected. For example, assume one tape is recorded with a standard guide position at room ambient temperature (both tape and guide stabilized at this temperature); then a second tape is recorded in the same headwheel panel assembly with the same guide position, but, in this case, the tape is 20° cooler. Next splice the two tapes together and let both sections stabilize at room ambient temperature before playing back. When played back, the guide position for no skewing will change by 0.0004 in. (calculated) between the two recordings. This substantial change is important. At present, the effects of temperature and humidity are not being taken into account in the SMPTE Recommended Practice. The need to do so is being studied. The alignment tapes currently made by both recorder manufacturers are made under relatively constant conditions of temperature and humidity. Thus these effects are minimized.

In order to make standard recordings, the tape recorder operator would need to know mechanical dimensions with great precision if he were to attempt to apply the standard recording condition directly. This is not a generally feasible approach to the problem. A more practical approach is to utilize an alignment tape which has been recorded at the standard recording condition and to achieve the proper adjustment by playing back this alignment tape and adjusting the vacuum guide position for complete absence of skewing and/or scalloping geometry distortion in the reproduced picture. When this has been accomplished, the vacuum guide position is standardized.

Appendix: Length of Recorded Video Track



L_r = length of recorded track
Θ_w = angle of wheel rotation
E = eccentricity of vacuum guide center of curvature and headwheel axis
R_g = radius of curvature of vacuum guide
T = tape thickness
Θ_g = angle of intercept at undeflected oxide surface measured at the vacuum guide center of curvature

The half length, $L_r/2$, of the average recorded track will correspond to the angle $\Theta_w = \pi/4$ radians. By inspection,

$$\frac{L_r}{2} = (R_g - T)\,\Theta_g \qquad (1)$$

Where Θ_g is expressed in radians.

$$\Theta_g = \Theta_w + \beta \qquad (2)$$

By trigonometric identity

$$\frac{E}{\sin \beta} = \frac{R_g - T}{\sin \Theta_w} \qquad (3)$$

Thus

$$\sin \beta = \frac{E \sin \Theta_w}{R_g - T} \qquad (4)$$

$$\beta = \sin^{-1}\left(\frac{E \sin \Theta_w}{R_g - T}\right) \qquad (5)$$

Since for $x \ll 1$ $\sin x = x$
and in this case $\dfrac{E \sin \Theta_w}{R_g - T} \ll 1$

$$\beta = \frac{E \sin \Theta_w}{R_g - T} \qquad (6)$$

Substituting from equation (6) into equation (2)

$$\Theta_g = \Theta_w + \frac{E \sin \Theta_w}{R_g - T} \qquad (7)$$

Further, substituting from equation (7) into equation (1)

$$\frac{L_r}{2} = (R_g - T)\left[\Theta_w + \frac{E \sin \Theta_w}{R_g - T}\right] \qquad (8)$$

Since the case of interest is the one for $\Theta_w = \frac{\pi}{4}$, this equation becomes

$$\frac{L_r}{2} = (R_g - T)\left[\frac{\pi}{4} + \frac{\sqrt{2}E}{2(R_g - T)}\right] \qquad (9)$$

This reduces to

$$L_r = \frac{\pi}{2}(R_g - T) + \sqrt{2}E \qquad (10)$$

In order to maintain L_r constant, an expression can be found which relates a change in E, which can be designated ΔE, to compensate for an incremental change in R_g, which can be designated ΔR_g.
Assume two conditions in which

$$L_{r_1} = \frac{\pi}{2}(R_{g1} - T) + \sqrt{2}\,E_1 \qquad (11)$$

and

$$L_{r_2} = \frac{\pi}{2}(R_{g2} - T) + \sqrt{2}\,E_2 \qquad (12)$$

If $L_{r_1} = L_{r_2}$

$$\frac{\pi}{2}(R_{g_1} - T) + \sqrt{2}\,E_1 = \frac{\pi}{2}R_{g2} - T) + \sqrt{2}\,E_2 \qquad (13)$$

Let

$$\Delta R_g = R_{g2} - R_{g1} \qquad (14)$$

$$\Delta E = E_2 - E_1 \qquad (15)$$

$$\frac{\pi}{2}(R_{g_1} - T) + \sqrt{2}\,E_1 = \frac{\pi}{2}(R_{g_1} - T) + \frac{\pi}{2}(\Delta R_g) + \sqrt{2}\,E_1 + \sqrt{2}\,(\Delta E) \qquad (16)$$

$$\frac{\pi}{2}(\Delta R_g) + \sqrt{2}\,(\Delta E) = 0 \qquad (17)$$

Therefore

$$-\Delta E = \frac{\pi}{2\sqrt{2}}\,\Delta R_g \qquad (18)$$

or

$$-\Delta E = 1.11\,\Delta R_g \qquad (19)$$

Time-Base Errors and Their Correction in Magnetic Television Recorders

By AUBREY HARRIS

During the recording process in a magnetic TV-recording system, the time relationships of the various parts of the signal waveform are transferred to the recording medium in elements of space. This operation, and the inverse, which occurs on reproduction, may cause undesirable time-displacement errors in the reproduced picture. The factors influencing these errors are outlined and discussed. Methods of reducing the errors and of increasing the time stability of the output signals by electromechanical and electronic means are described.

In a magnetic television recorder the electrical waveform is laid down on a tape so that the original time scale of the waveform is transformed. The recording process allocates to each unit of time in the waveform a corresponding unit of space on the tape. On reproduction these recorded elements are converted back into units of time. During the processes of translating the waveform onto and off the tape, errors in timing may occur which affect the geometry of the reproduced picture and/or its stability with respect to a stable reference source.

The errors in timing stability may be classified broadly into two main types: (a) fixed or static errors and (b) dynamic errors. Dynamic errors may be further subdivided into: (1) cyclic errors and (2) random errors.

1. Timing Errors

Fixed errors are due to misadjustment of the mechanical parts of the video-head assembly. These discrepancies may be: (1) unequal angular placement of the four video-head tips (quadrature error), (2) inconsistency of video-head tip penetration into the tape during the recording and reproduction processes (skewing), and (3) incorrect vertical guide height setting (scalloping).

In general, the static errors show as fixed geometric displacements of various areas of the image and the dynamic errors are manifested as jitter, or an oscillatory horizontal motion of the complete picture across the display screen. It is quite possible, by good operational procedure, to eliminate all traces of the static, geometric errors beyond visible perception. This may be accomplished by the adjustment of the video-head assembly to a standard alignment tape. The timing errors cause distortion of the reproduced picture, and any or all of them may be present in a system at any one time.

1.1 Quadrature Error: If the angular spacing between each adjacent pair of video-head tips on the head-drum wheel is not exactly equal ($\theta a = \theta b = \theta c = \theta d = 90°$), then the time intervals between the starts of sweeps of successive head tips will vary. A tape reproduced on the head which was used for the recording, with each head tip replaying the same track as it recorded, would show no geometric error.

However, if the tape were reproduced with a head different from that used for recording, or if the same head were used and each head tip were allowed to replay a track other than that which it recorded, then timing errors would show in the reproduced picture (Fig. 1). The errors would be proportional to the sum of the angular spacing errors of particular pairs of adjacent head tips.

A timing error of 0.1 μsec would be caused by an angular error of approximately 30 sec of arc, which represents a displacement of the order of 150×10^{-6} in. at the drum periphery. Quadrature errors can be completely eliminated by the correct and accurate adjustment of the angular positions of the video-head tips.

1.2 Skewing: Skew distortion is caused when there is a different amount of tape stretch due to video-head tip penetration between recording and reproduction. Consider, for example, that the tip penetration is greater and therefore the tape is stretched more during the reproducing process than on recording.

The length of the recorded tracks, and thus each television line, is greater during reproduction than it was during recording. Assuming the same angular velocity of the head-drum wheel during its sweep over a complete track, the time taken for a head tip to scan a line will be longer by an amount proportional to the additional tape stretch. When a picture reproduced under such conditions is displayed on a monitor having horizontal sync circuits which respond only to the average sync pulse timing, the image shown is split into bands of 16 to 17 television lines, each

Presented on May 11, 1961, at the Society's Convention in Toronto by Anthony Beddon, Ampex of Canada, for the author, Aubrey Harris, Ampex Great Britain Ltd., Arkwright Rd., Reading, Berks, England.
(This paper was received on April 20, 1961.)

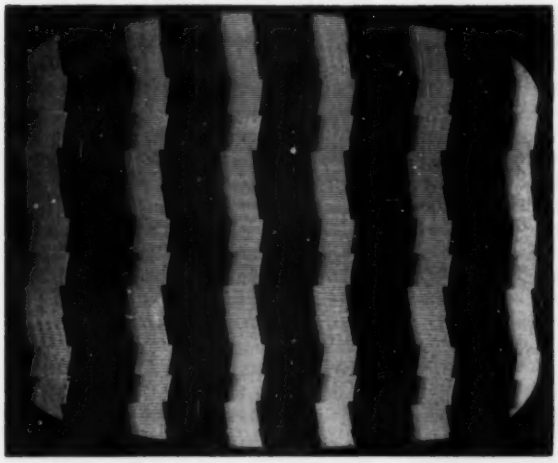


Fig. 1. Excessive quadrature error.

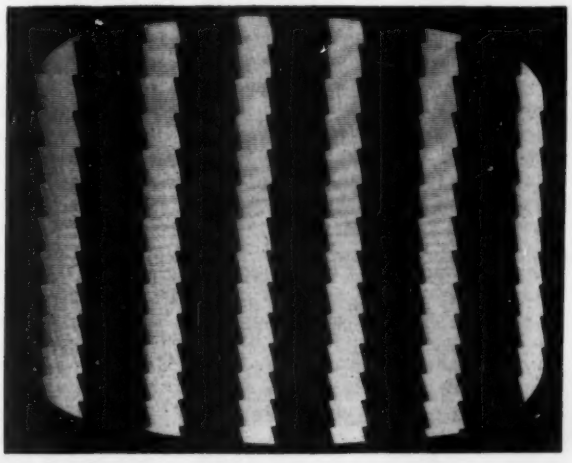


Fig. 2. Skewing distortion.

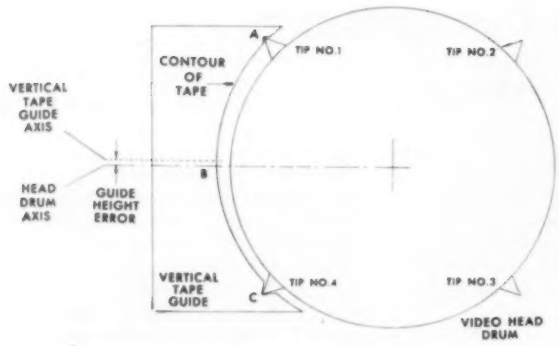


Fig. 3. Vertical tape guide alignment too high.

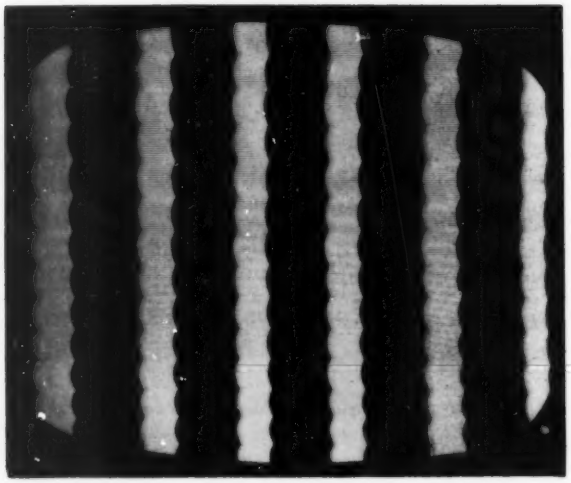


Fig. 4. Vertical guide position too high.

band corresponding to the sweep of one video head across the width of the tape. The start and finish times of the lines in each band are progressively delayed, the band of lines appears of rhomboid shape and the picture suffers from skew distortion. An illustration of this is shown in Fig. 2.

1.3 Scalloping: An effect known as scalloping is apparent when the position of the concave vertical tape guide, relative to the axis of the video-head wheel, is incorrect.

Assume that the vertical guide height is set too high (that is, the axis of the head wheel is below the horizontal radius of the concave portion of the vertical guide), and that the tip penetration is correct. The periphery of the video-head tips on the head wheel is no longer concentric with the vertical guide contour (see Fig. 3). The penetration of head tip No. 1 when it starts its sweep at the top edge of the tape (A) is less than it should be. The penetration is approximately correct when the head is midway through its sweep (B) and is greater than normal as the head finishes its sweep at (C). This results in a repetitive variation of tip penetration which changes smoothly as each head tip traverses the tape, from less than normal through normal to greater than normal. The effect on a reproduced image is shown in Fig. 4. If the vertical guide height were set too low, then the scallops would be formed in the other direction.

1.4 Dynamic Errors: Cyclic errors are caused by hunting of the head drum, capstan or spooling motors due to the inherent electrical and mechanical characteristics of these motors. These errors are indicated by damped or undamped periodic time displacements in the reproduced signal.

Variations in the friction between the video-head tips and the tape itself will cause unpredictable changes in the angular velocity of the video-head wheel, producing random errors.

Reproduced dynamic errors, when using a normal head-drum motor servo control system, may be typically 0.5 μsec peak-to-peak, with a maximum tolerable error of up to 2 μsec peak-to-peak. This variation occurs generally between 5 and 10 cps, the limits of the mechanical resonance of the video-head drum. The angular position of the head drum is continuously indicated by the phase of a 240-cps timing signal generated by a lamp and photoelectric cell system on the drum shaft. This signal is compared with a reference signal of the same frequency. Any error so detected is used as a control signal to correct the phase of the head drum drive signal, thus tending to compensate for the angular position error. A discriminator circuit is also used to reduce errors due to video head hunting.

2. Reduction of Errors

The correction possible with this type of drum servo control is quite adequate for broadcast transmission where the transmitted video and sync signals are derived simultaneously from the same recorded tape.

There is a requirement, however, for a television magnetic tape recorder to be operated in the studio center as a synchronous source. That is to say, the recorder should be capable of being locked to the studio sync generator, and the reproduced noncomposite video output should be of adequate time stability to allow the addition of sync signals at some later point in the transmission chain. This permits the recorder to be used as a source of signal in the same manner as studio cameras, telecine machines, caption scanners and other studio equipment. Cross-fades, superimpositions, inlay and overlay effects may then be used between the recorder and these other sources.

The time stability necessary for such operation should not be worse than 0.1 μsec peak-to-peak. This stability is obtained by the use of two items, the Television Signal Synchronizer (Intersync*) and the Time Element Compensator (Amtec*). The degree of stability possible with the former is 0.15 μsec peak-to-peak and with both units simultaneously in use, 0.01 μsec peak-to-peak.

The Synchronizer may be said to be electromechanical in operation because the corrections are made by modifying the phase of the head-drum motor drive signal. The Compensator is completely electronic and acts by applying a varying delay to the video waveform. These devices will be considered in greater detail.

3. The TV Signal Synchronizer

It will be appreciated that in order to derive maximum compensation of a timing error in a reproduced signal, it is desirable to sample the error as frequently as possible. The errors produced are due to, and thus are indicated by, the angular position of the head drum. However, sampling at the rate of 240 cps is not sufficiently often to give the required amount of correction. Sampling at this rate allows approximately 65 TV lines to pass uncorrected between sampling instants. A higher and far more satisfactory sampling rate is at the frequency of the horizontal sync pulses. The error may be detected by the time comparison of the sync pulses from the studio sync generator, which is used as a reference, and those being reproduced from the tape. Any difference in time between the two sets of pulses is converted into an error signal which is used to modify the phase of the head-drum drive signal in order to eliminate the timing error.

It should be noted that a device which samples at such a rate is unable to de-

*Trade Marks, Ampex Corp.

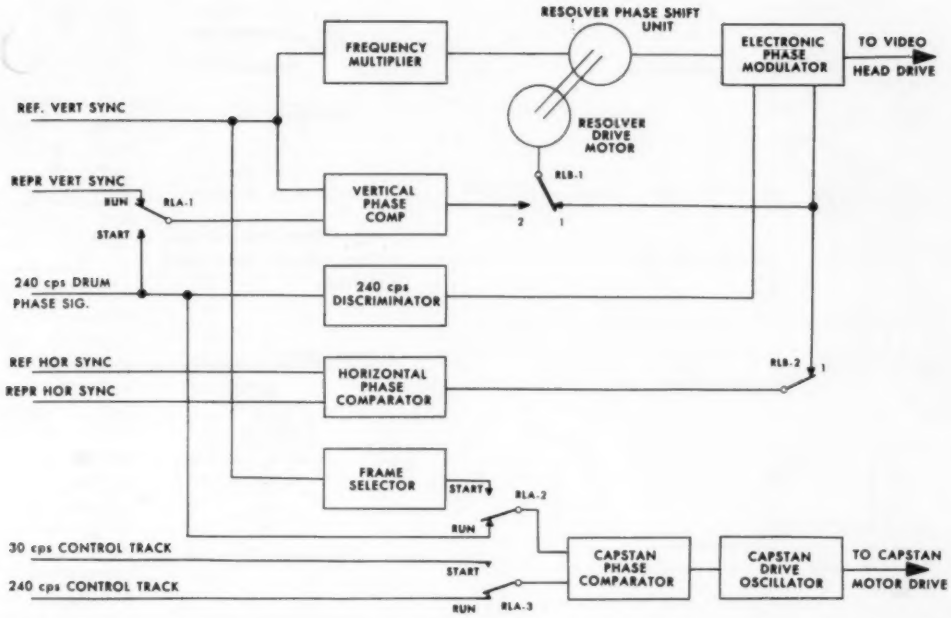


Fig. 5. Synchronizer reproduce mode.

termine whether the error it is detecting is, for example, equal to one tenth of a television line, $1 + 1/10$ or $n + 1/10$ TV lines. If the error were as great as one-half of a line there would be ambiguity as to whether the particular sync pulse was half a line "early" or half a line "late." Therefore, it is necessary initially to determine the coarse error and make a suitable correction before the higher frequency, fine correction, is applied.

3.1 Method of Correction: This ambiguity reduction is effected into two stages: first, the capstan drive circuit is controlled in frequency and phase so that the plane of the video-head wheel is correctly positioned to scan the video track containing the frame sync information. Second, the 240-cps drum reference (photocell) signal is compared in time relationship to the reference vertical sync pulses. The error signal so derived is used to phase the head drum position so that the reproduced vertical sync pulses are in time coincidence, ± 15 μsec, with the reference vertical sync pulses. Figure 5 is a block diagram of the method of deriving and controlling the video-head drum and capstan motor drive signals during the reproduction process.

Let us consider initially the capstan drive system. The frequency of the oscillator supplying the capstan motor drive signal is capable of adjustment by a d-c voltage derived from the capstan phase comparator. During the commencement of the reproduction of a tape the contacts of relay RLA are at the "start" position. A prerecorded 30-cps frame pulse (superimposed on the 240-cps control track) is compared in phase with a similar frequency pulse derived from the reference vertical sync pulses. The 30-cps frame pulse on the control track is, during the recording process, laid down in a specific relationship to the recorded frame sync pulses. On reproduction, time comparison of this pulse with the reference pulse produces a control signal voltage which varies the capstan oscillator frequency. This frequency is thus adjusted and the longitudinal position of the tape is controlled so that the plane of the video heads is colinear with the video track containing the recorded frame sync pulses.

This correction is completed in less than 3 sec. At approximately $3\frac{1}{2}$ sec after the start has been initiated the contacts of relay RLA move to the "run" position. In this condition the capstan oscillator frequency is controlled by a signal derived from the time comparison of the 240-cps drum phase signal and the 240-cps control track signal.

The higher rate of sampling gives a finer degree of control than is possible with the 30-cps signals used during the initial condition. Additionally, the use of the 240-cps control track for control of the capstan drive permits the use of a simple existing method of tracking adjustment.

Referring again to Fig. 5, the 240-cps video head-drum drive signal is derived by the frequency multiplication of the 60-cps reference vertical sync frequency. After multiplication, the signal is applied to a resolver phase shift unit and then a phase modulator, prior to being fed to the video head-drum drive motor.

3.2 The Resolver Phase Shift Unit: The resolver phase shift unit consists of a resolver proper and a servo drive motor to which amplified error signals are fed. The 2-phase drive motor is coupled to the resolver rotor shift through 100:1 reduction gearing.

The resolver itself has a single rotor input winding and two stator output windings in quadrature. By suitably combining the two stator signals a constant amplitude output is obtained, the phase of which, relative to the input, is a function of the angular position of the rotor.

The resolver servo drive motor is fed with an error voltage produced by the vertical phase comparator. The two inputs to this comparator during the "start" sequence are the reference vertical sync signals and the 240-cps drum phase signal. The drum phase signal is sampled by pulses derived from reference vertical sync pulses in the vertical phase comparator. It is the error voltage obtained by this sampling that is used to operate the resolver servo motor. The motor through its gearing turns the resolver rotor, adjusting the phase of the drum drive signal. The error voltage driving the motor falls to zero when the drum is so positioned that a specific video head is correctly located to pick up the recorded vertical sync signals.

After the $3\frac{1}{2}$-sec start period and the contacts of relay RLA move to the "run" condition, the vertical phase comparator samples reference with reproduced vertical sync pulses.

There are two reasons for utilizing the drum phase signal for the comparator during the start period. For the first $1\frac{1}{2}$ sec after the start there is no information being reproduced from the tape; therefore, reproduced sync information is not then available. Also, it is possible, due to the specific relationship of the drum phase signal and the video-head tips, to position these approximately in the center, laterally, across the tape.

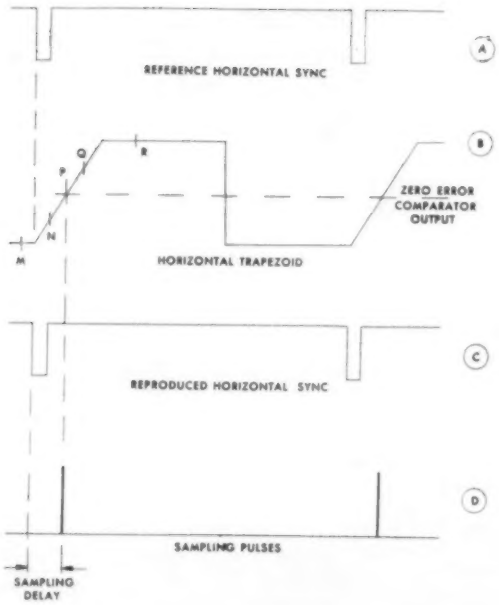


Fig. 6. Horizontal comparator waveforms.

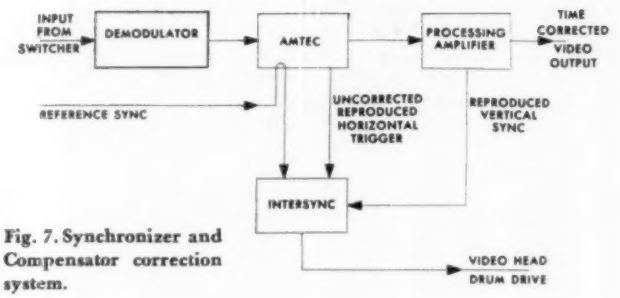


Fig. 7. Synchronizer and Compensator correction system.

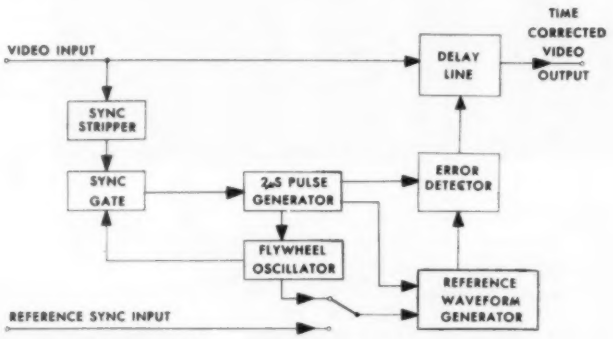


Fig. 8. Time Element Compensator.

The switch from the drum phase signal to the reproduced signal is made for the running condition because it is the stability of the latter which is the prime requirement. By the use of the drum phase signal the reproduced vertical signals are made to occur within ±15 μsec of the reference vertical signal.

The resolver phase shift unit is capable of making continuous (that is, throughout 360°) corrections of phase, either lagging or leading the phase of its input signal. The input to this unit is a correction signal from either the vertical or horizontal phase comparators.

3.3 The Phase Modulator: Two inputs are fed to the phase modulator: (a) a frequency correction signal which is produced by the 240-cps discriminator, and (b) a signal corresponding to the horizontal phase error between reference and reproduced horizontal sync pulses.

The 240-cps discriminator produces an output voltage which is proportional in frequency and phase to the variations from 240 rps of the drum velocity. These variations are mainly caused by the natural mechanical characteristics of the video head-drum motor. They show up as an oscillatory error of between 5 and 10 cps. By applying this error signal to the phase modulator the variations are effectively critically damped.

The other input to the phase modulator is from the horizontal phase comparator. This derives an error voltage which is a measure of the line-by-line time difference between reference and reproduced horizontal sync pulses. This correction voltage is applied to the phase modulator and also the resolver phase shift unit. Relay RLB, at the output of the vertical phase comparator normally releases (to position 1) at the same time as relay RLA changes over to the "run" position.

It is the fine correction derived from the horizontal phase comparator, applied to control the phase of the video head-drum drive signal, which enables the necessary stability of the output waveform to be obtained.

3.4 Synchronizing Discontinuity: There is the possibility of the interruption of the reproduced signal due to an imperfect splice or a join between two pieces of tape without regard to the maintenance of sync continuity. This may cause the output of the vertical phase comparator to increase suddenly. If the increase is caused by a timing error of greater than about two lines (125-130 μsec) RLB operates and removes the horizontal correction from the resolver phase shifter and the phase modulator. The resolver phase shifter is then temporarily driven by the vertical phase comparator until coincidence (±15 μsec) is once again achieved.

3.5 Correction Sequence: It is convenient to summarize the stages in the achievement of absolute time coincidence between the reference and reproduced signals. See Table I.

3.6 Phase Comparators: Reference is made in Table I to the capstan, vertical and horizontal phase comparators. Although operating at differing frequencies their working is basically similar. The operation of the horizontal phase discriminator will be given as an example. Figure 6 shows the significant waveforms.

A trapezoid signal (B) is produced from reference horizontal sync signals (A). The amplitude of this trapezoid is 20 v peak-to-peak. Reproduced horizontal sync signals (C) are delayed and differentiated (D). The differentiated reproduced pulses are made to sample the reference trapezoid in a transistor comparator circuit. It is so arranged that the delayed, reproduced, sampling pulse falls at the midpoint (P) of the trapezoid when there is no error between reproduced and reference sync signals. Under this condition the output voltage from the comparator is zero. Should a timing error be present, the pulse samples the trapezoid on a different portion of the slope. This gives an output voltage proportional to the amplitude and phase of the error (points N, Q). This voltage is fed to the correction circuit, the amount of

Table I.

Capstan phase comparator, 30 cps	Determines which single track out of 32 tracks contains the frame sync signals	±500 μsec
Vertical phase comparator, 240/60 cps	Positions video-head drum with respect to reference vertical sync pulses	±15 μsec
Horizontal phase comparator, 15,750 cps	Adjusts phasing of reproduced waveform	±0.15 μsec

correction being a measure of the error voltage magnitude. If the timing error is great enough so that the sampling pulse no longer lies on the linear rise of the trapezoid but on the constant voltage part of the waveform (points M, R) maximum error voltage is produced. When this voltage is applied to the correction circuit rapid reduction of the error is made, bringing the sampling pulse onto the gradient of the trapezoid waveform.

4. The Time Element Compensator

The Synchronizer unit itself is capable of making corrections so that the reproduced sync waveform differs by no more than ± 0.15 μsec from the reference waveform. An improvement in this stability is obtained by the use of the Compensator. The method of incorporation of this unit into the reproducing system is indicated in Fig. 7.

The Time Element Compensator may be used in one of two modes. In the first or "geometry correction" mode, error detection is accomplished by comparing the timing accuracy of the reproduced signal with a stable timing reference derived internally from the average time rate of the demodulator output. As a result, repetitive geometric errors of 0.5 μsec peak-to-peak are reduced to less than 0.02 μsec peak-to-peak. The resulting picture element displacement, after correction, is visually undetectable. Corrections of this degree remove the last element of uncertainty in the consistent achievement of complete interchangeability and interspliceability.

The second mode utilizes the unit in conjunction with the Synchronizer. Error detection in this mode is accomplished by comparing the timing accuracy of the playback signal with a stable external timing reference, such as the output of the local station sync signal generator. As a result, the overall system not only corrects picture geometry distortion, but also synchronizes the playback signal with the external reference. The same instantaneous time correction accuracy is achieved, as in the previous mode of operation, while the low rate timing accuracy of 0.01 μsec peak-to-peak is maintained with respect to the reference signal.

A simplified block diagram of the Compensator is shown in Fig. 8. The essential feature of this unit is a voltage-controlled delay line. This delay line is in the direct video path of the reproducing system and the amount of delay inserted is a function of the applied correction voltage.

The incoming (uncorrected) horizontal sync signal is stripped from the video waveform. This is fed to a gate circuit which allows the leading edge and most of the horizontal sync pulse to pass. The gating waveform is derived from a reactance-tube-controlled flywheel oscillator operating at the horizontal frequency. The output of the gate after filtering and clipping is used to generate a 2-μsec rectangular pulse. This pulse is routed to the phase comparator controlling the flywheel oscillator, the reference waveform generator and the error dectector.

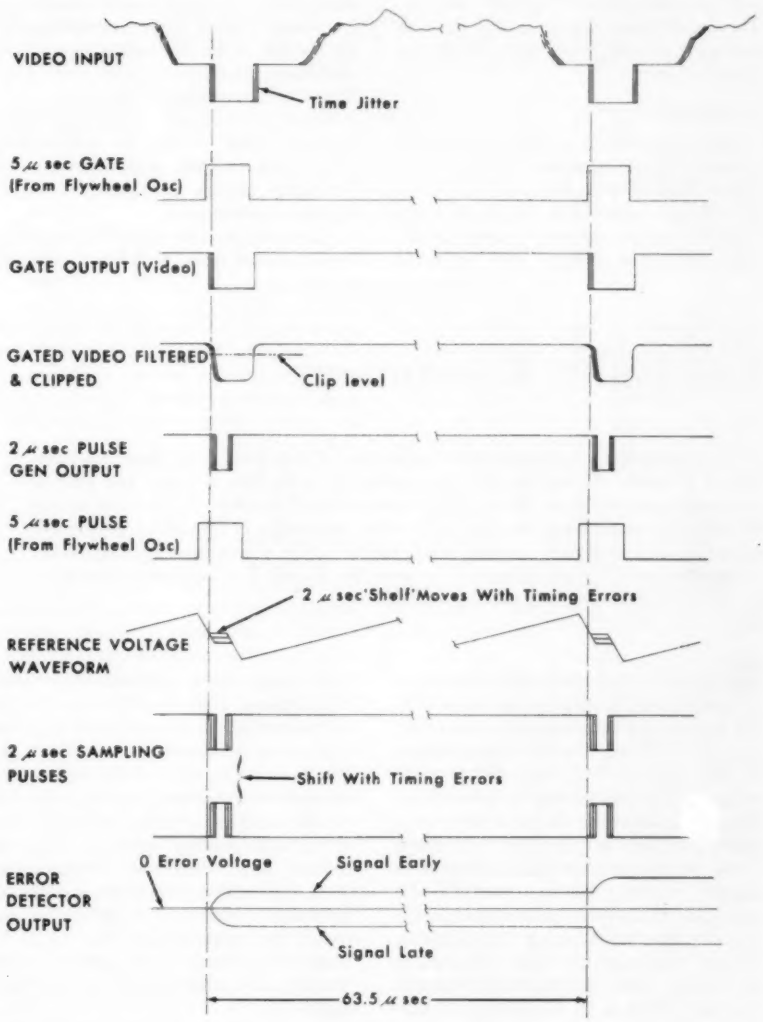


Fig. 9. Waveforms of Time Element Compensator.

The reference waveform generator produces a sawtooth signal at horizontal rate with a "run-down" time of 5 μsec. This is derived either from the flywheel oscillator (which corresponds to the average rate of the incoming horizontal sync pulses), or from a stable external reference source. Upon this sawtooth is superimposed the 2-μsec pulse derived from the sync gate output. This combination forms a "shelf" in the waveform (see Fig. 9). As the sync gate output contains the time instability of the input signal this shelf will move in time and will appear at a varying amplitude point on the sawtooth.

The sawtooth-shelf waveform is sampled in the error detector by the same 2-μsec pulse derived from the sync gate. The "shelf" and the sampling pulse move together in time and the output of the error detector is a varying voltage, the amplitude and phase of which is a function of the time error of the input signal. The output voltage from the error detector is fed to the delay line so that an increase in delay is effected by an "early" signal and a decreased delay is the result of an error signal derived from a "late" signal.

Thus, the output video signal of the Compensator is corrected in time, line by line, by the detection of the timing error at the start of each horizontal sync pulse. The inserted delay is the precise opposite of the original timing error in the reproduced signal and thus causes error cancellation.

The delay line itself is comprised of a number of lumped constant sections. The capacitative components are silicon junction capacitors which have the property of changing their capacitance

with a variation of applied voltage. The total timing error, which may be corrected by the delay line, is not less than 1.0 μsec.

5. Conclusion

During the recording and reproduction processes in a magnetic television recorder, time-base errors may be introduced by video-head misalignments, variations in mechanical loading of the tape and other factors. The inevitable distortion of the reproduced image may be reduced below subjective recognition by the use of the Television Signal Synchronizer (Intersync) and the Time Element Compensator (Amtec).

Intersync reduces horizontal jitter (greater than 1 cps) to within 0.15 μsec peak-to-peak and slower rate horizontal picture movements to within 0.5 μsec peak-to-peak.

Amtec corrects for repetitive geometric timing errors of up to 0.5 μsec peak-to-peak so that the remanent geometrical error is less than 0.02 μsec peak-to-peak.

Additionally, Amtec used in conjunction with Intersync reduces horizontal jitter and slower rate horizontal picture displacements down to less than 0.01 μsec peak-to-peak.

Acknowledgments

Thanks are due to D. MacLeod and C. Coleman for their help and advice in the preparation of this paper.

Cablefilm Equipment

By C. B. B. WOOD, S. H. PADEL and PETER RAINGER

The equipment is intended for the transmission of short lengths of 16mm news film over a program channel in very long cables or radio link systems. The time of transmission is 100 times the normal running time of the film. The corresponding reduction in bandwidth together with other economies in frequency enable the signal to be restricted to a video bandwidth of 4.5 kc which occupies a band between 0.5 and 5.5 kc for transmission over the circuit. The equipment has been successfully used over the transatlantic cable.

EXTENSIVE FACILITIES exist throughout the world for the distribution of news in the form of the written and spoken word. Similar facilities provide facsimile copies of still pictures, but until the development by the Engineering Division of the British Broadcasting Corp. of the equipment described in this paper had taken place, no comparable facilities existed to supply motion pictures suitable for presentation in their news transmissions by television broadcasting organizations. Except where a television network is available, news pictures are usually supplied on film. In an attempt to provide a quicker news service, it was decided to develop a facsimile process for use with certain music circuits. The equipment to be described is capable of providing copies of short lengths of 16mm news film with the minimum delay.

1. Picture Standards

From the beginning of the development of this equipment it was clear that one of its most important uses would be to exchange news pictures across the Atlantic between Europe and America. Accordingly, the characteristics of the music circuits which exist in the transatlantic cable between New York and Montreal on the one hand, and London on the other, largely determined the transmission characteristics of the system. It appears that a typical item of a news program is approximately thirty seconds long. If the facsimile system is to be successful, its transmission time for this amount of film should not exceed say one hour, i.e., a ratio of 120 : 1 between the playing time and time of transmission by the facsimile process. It follows that everything possible must be done to reduce the bandwidth requirements since the ratio between the bandwidth associated with a normal television signal, for example, and the 6.4 kc of bandwidth which is available on the transatlantic music circuit is more like 1,000 : 1.

It was, therefore, necessary to choose picture standards requiring the minimum bandwidth commensurate with reasonable picture quality. Previous experience indicated that a 200-line picture would be acceptable, and that each line should contain about 360 picture elements. A further economy has been obtained by portraying motion at the rate of 12 pictures/sec, although the number of complete pictures transmitted per second must, of course, remain at 25 for the eventual broadcast in order to avoid brightness flicker.

With these major decisions taken, the details of the standards finally used followed almost automatically. These details are listed in Table I. (The considerations which led to a choice of 4.5 kc for the video bandwidth will be discussed in Sec. 3 which deals with the line transmission equipment.) This choice of standards has led to each single frame of the film requiring a transmission time of 8 sec. This, together with the fact that only 12 frames are transmitted, where normally double this number would be employed were normal information about motion being sent, means that the time of transmission is approximately 100 times greater than the eventual playing time of the film.

With these standards in mind it was possible to commence the design and manufacture of suitable equipment. Briefly, it was necessary to make a film scanner which could generate a television type waveform of sufficiently small bandwidth. The transmission equipment, in turn, had to translate the video signal so that its spectrum fell within the passband of the cable. Then, after transmission, the signal had to be converted back to video frequency and recorded on 16mm film.

2. Film Console

The film console is basically a 16mm slow speed, flying spot film scanner or, alternatively, a 16mm telerecording channel, the same piece of equipment performing either function at choice.

2.1 Film Traction Mechanism

Wherever possible in the equipment, the design is such as to give some degree of flexibility. This equipment is in many ways a new venture and circumstances may arise when it is desirable to change the picture standards employed. One good example of this occurs in the film traction mechanism. Under normal conditions of working only every other picture is transmitted, each picture being recorded in duplicate at the receiving end. This produces a film capable of

Table I. Picture Standards.

Number of lines per field	200 sequentially scanned
Line scan frequency	25 cps nominal
Number of picture elements per line	360
Interline blanking period	6 msec
Interfield blanking period	100 msec
Duration of each frame or picture scan	8 sec
Maximum video signal frequency	4.5 kc

Presented on October 9, 1959, at the Society's Convention in New York by C. B. B. Wood, S. H. Padel and Peter Rainger (who read the paper), Research Dept. and Designs Dept., British Broadcasting Corp., Broadcasting House, London W.1, England.
(This paper was received in final form on May 8, 1961.)

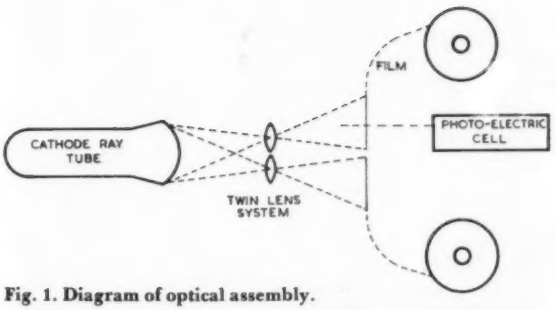


Fig. 1. Diagram of optical assembly.

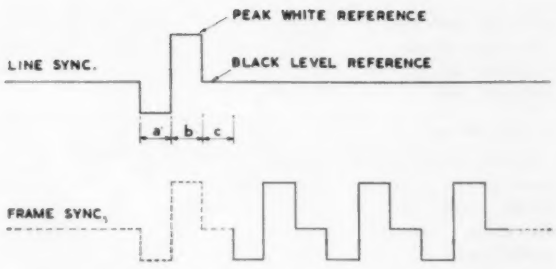


Fig. 2. Synchronizing waveform.

being used in a normal projector, i.e., at 24 pictures/sec. If, however, the film to be transmitted has a subject which moves quickly, it may be desirable to transmit the full number of pictures. In this case the sending and receiving equipment can be switched to operate frame by frame. The intermittent mechanism which drives the pull down claw and the associated sprockets is essentially a magnetically triggered clutch, transmitting the power provided by a small induction motor. The electrical triggering signal can be modified so as to make the clutch perform either one or two revolutions as required.

2.2 Optical Assembly

Figure 1 is a diagram of the optical assembly and associated equipment. In the send condition, only one lens is in use and the equipment operates as a flying spot scanner. In the receive condition, the photocell is no longer required and both lenses are used to record two images of the film. Great care has to be taken to ensure that these two pictures are as near identical as possible and in the correct position, since any discrepancy will introduce a 12-cps flicker.

2.3 Electrical Equipment

(1) *The Waveform:* More or less conventional master oscillator and dividers produce line and field pulses which drive the waveform generator, the latter in turn producing the necessary synchronizing signals for blanking waveforms.

In normal television an occasional failure or irregularity in the synchronizing signal can often be tolerated. Unfortunately the time scale in the proposed system is such that a faulty signal of this form could be most objectionable. Therefore, each transmission requires a signal maintained an hour or more without even momentary faults. As in some circumstances where the signal could be subject to considerable noise or other interference signals, there was a need for a very strong and robust synchronizing system. The waveform employed is shown in Fig. 2. The line waveform is similar to that used in television broadcasting systems except that a further pulse has been added immediately after the synchronizing pulse. This pulse commences with the timing edge which extends from the bottom of synchronizing signal to peak signal; then, immediately after this edge there are two reference levels, one at peak white and the other at black level. The complete synchronizing waveform is about 6 msec long, which is equivalent to approximately 50 picture elements. As a result the number of active picture elements is, in fact, less than 360. This information is available for synchronizing, blanking, providing the appropriate reference levels, and also giving an opportunity for obtaining the reference carrier required later in the demodulating equipment. The circuits employed are such that the liability to interference, etc., is improved by some 10 db over that realizable with a normal synchronizing waveform.

The waveform in the lower part of Fig. 2 illustrates the frame synchronizing waveform. This consists essentially of a further three line sync pulses in rapid succession.

(2) *Scanning Circuits:* To complete the description of the film console it should be explained that two cathode-ray tubes are used, one to provide the scanning raster and the other, with a long afterglow phosphor, to provide a monitoring picture. Magnetic deflection is employed on both of these tubes.

The very low frequency frame scan is provided by a direct feed to a specially designed scanning yoke. A permanent magnet shift arrangement is provided to allow the picture to be centered in its correct position.

(3) *Video Circuits:* Figure 3 is a block schematic of the video equipment. This includes a nonlinear correction for the various film processes required. The equipment normally transmits a negative film and produces the appropriate positive film at the receiving end. If desired, however, a positive can be transmitted and again a positive is reproduced at the receiving end. In both these cases the signal is, in fact, sent to line as a negative picture. When a positive film is employed, the electrical signal is corrected by a nonlinear network at the sending end in such a way as to make it appear that it has originated from the corresponding negative. It is evident that the equipment employs a technique very similar to that used in normal television practice.

The problem of mains interference presented a major difficulty throughout the design of this equipment. Hum on the picture appears as a relatively high frequency pattern which cannot be removed by clamps and similar circuits.

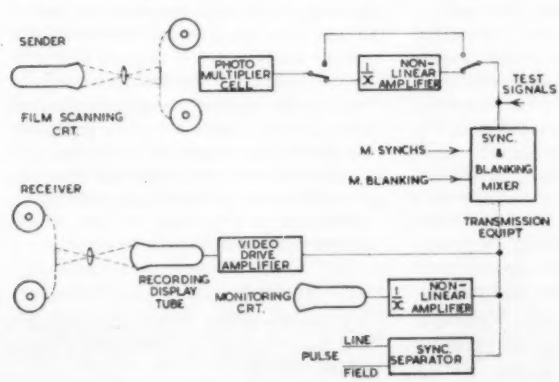


Fig. 3. Block schematic of video equipment.

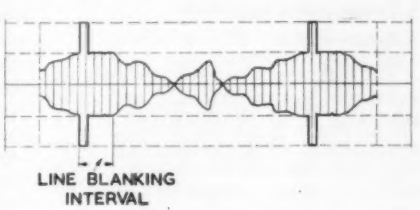
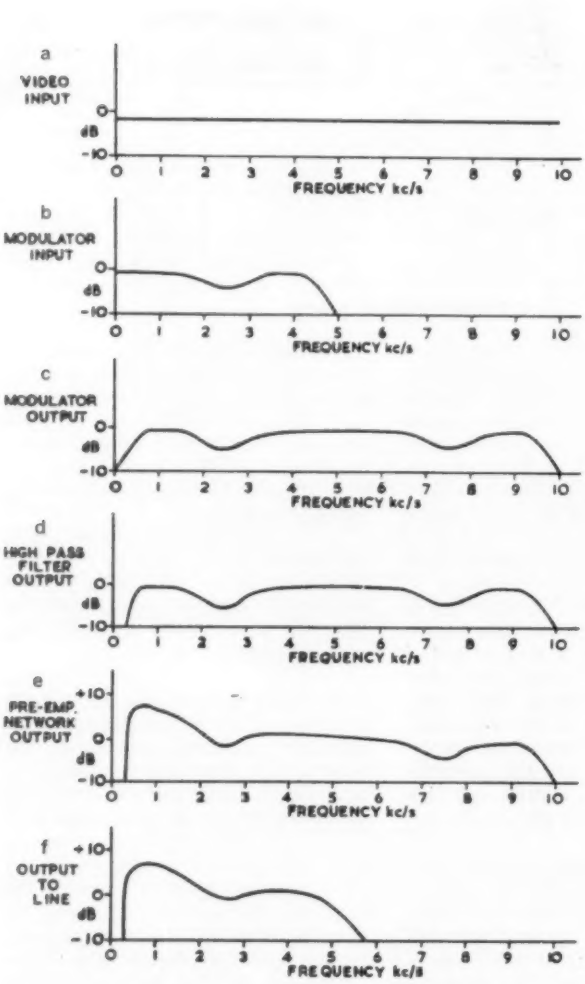


Fig. 4. Envelope of modulated carrier.



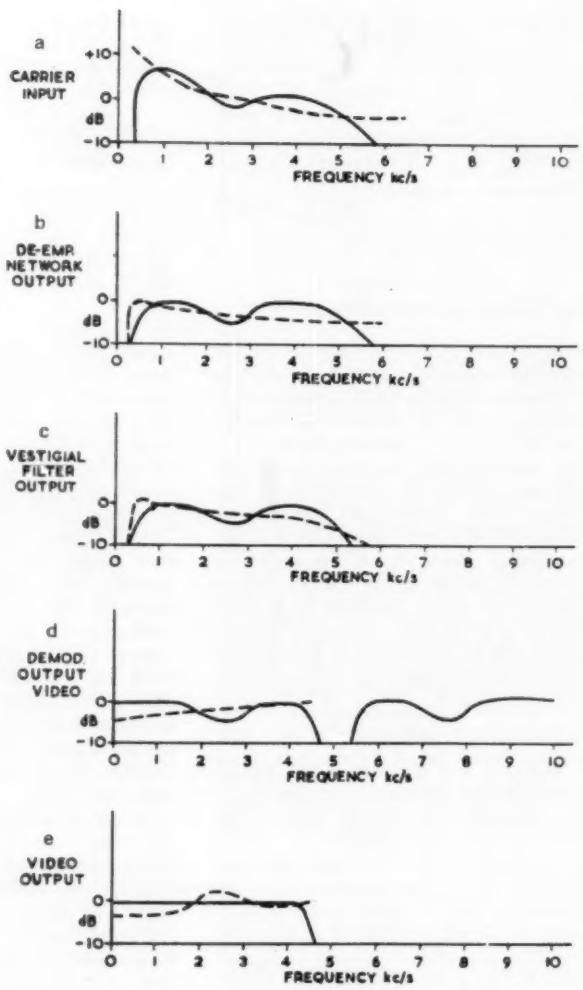


Fig. 5. Send terminal spectrum diagrams; and Fig. 6. (right) — Receive terminal spectrum diagrams: Decible scale = 10 db/cm, ——signal spectrum, - - - -noise spectrum.

The low hum levels required can then only be achieved by careful design and extensive use of magnetic screening. For example, the cathode-ray tubes described previously are surrounded by a double mumetal screen and all mains transformers are mounted in a separate cubicle several feet away.

3. Transmission Equipment

3.1 Introduction

The first step in the design of suitable equipment was to determine the amplitude and delay characteristics of the music circuit. Measurement of the noise level and noise spectrum was also made with the volume compandors normally used on music and speech out of circuit.

It was clear from these results that some equalization of the amplitude/frequency characteristic and considerable equalization of the delay/frequency characteristic would be necessary. Even with equalization, the delay distortion at each end of the band would limit the usable bandwidth to about 5.0 kc, extending from 500 to 5,500 pulses/sec. It had already been decided that an amplitude modulated vestigial sideband system would be used and accordingly a carrier frequency of 5 kc was chosen, the spectrum occupied by the signal being shaped to fall within the band from 500 to 5,500 pulses/sec. In order to obtain the best signal-to-noise ratio, the modulation factor exceeds unity and that part of the modulation envelope which extends beyond zero carrier is "folded back" in a positive-going direction. The modulation factor is, however, limited to 3.3 in order to simplify the terminal equipment. This type of signal requires synchronous demodulation; and, this type of demodulator has the subsidiary advantage of producing the minimum quadrature distortion normally associated with the demodulation of a vestigial sideband signal. The synchronous demodulation is achieved by using an oscillator whose frequency is controlled by the incoming carrier frequency, as gated once per line. The gating waveform is, incidentally, obtained by envelope demodulation of the incoming signal. Figure 4 illustrates a typical envelope of the modulated carrier. It will be seen that the amplitude falls to zero at a point corresponding to approximately 50% of the picture signal range and then reverses in direction; at maximum picture voltage, the amplitude of the modulated carrier is again nearly as great as at zero picture voltage. The two parts of the modulated carrier envelope disposed about the zero point are characterized by a difference of phase of π radians. The synchronous detector is able to recognize this difference of phase, in addition to differences in amplitude, so that the required video waveform is obtained.

3.2. The Sender

Referring to Fig. 5, the video signal is first band limited to 4.75 kc in a phase corrected filter.

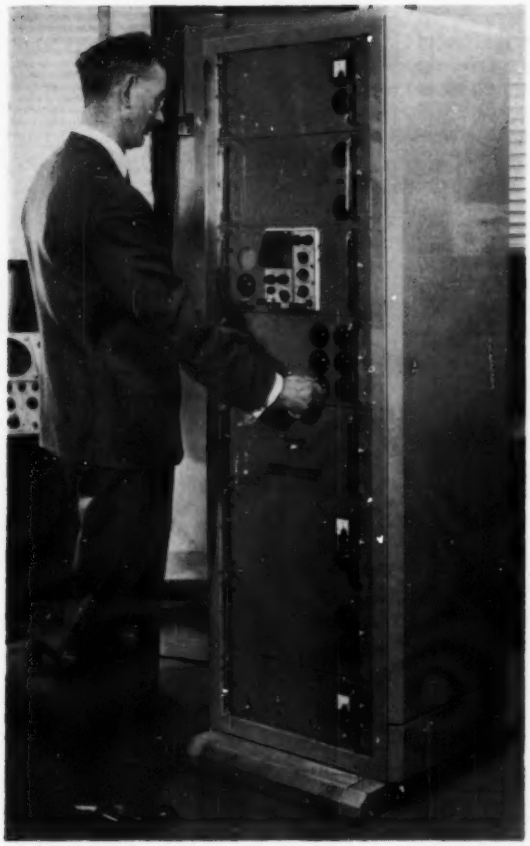


Fig. 7. Line translating equipment.

Fig. 8. Film scanning equipment.

The spectrum of the signal after it has been through this filter and associated video pre-emphasis network is shown in Fig. 5(b). This pre-emphasis network is a resonant equalizer having a maximum loss of 4 db at 2.5 kc. It is used to reduce the level of video components around this frequency which might otherwise produce unwanted intermodulation effects in the modulator. The carrier supply for the modulator is provided by a 5-kc crystal oscillator unit and buffer amplifier.

A relatively simple form of direct modulation is employed. A good balance is achieved and the resulting signal is free of unwanted interference, etc., even though the frequency spectrums of the input and output signals overlap, Fig. 5(c).

The output from the modulator then passes through the following three networks:

(1) A 400-cps high pass filter to remove low-frequency components, especially those due to mains hum, Fig. 5(d).

(2) A modulated signal pre-emphasis network. This network has a slope of approximately 3 db/octave over the required band and raises the low frequency components with respect to the carrier, thus partly compensating noise characteristics of the transatlantic cable, Fig. 5(e).

(3) A 4.85-kc linear phase vestigial sideband shaping filter which has a loss of 3 db at the carrier frequency and provides half the total shaping necessary in the overall system, Fig. 5(f).

Finally, the signal passes through a regulating amplifier which automatically adjusts the level of the signal sent to line.

3.3 The Receiver

Figure 6 shows the position of the signal in the frequency spectrum in various parts of the receiving equipment.

The received carrier signal passes first through the amplitude and delay equalizers which compensates for much of the distortion of the music channel. Most of the distortion is corrected by fixed equalizing networks but a two-section variable amplitude equalizer is included together with a six-section variable delay equalizer. These variable equalizers are adjusted while observing the test waveforms on an oscilloscope provided for this purpose. The signal then passes through a 400-cps high pass filter, a modulated signal de-emphasis network (complementary to the pre-emphasis network used in the sender), and the linear phase vestigial sideband shaping necessary for vestigial sideband transmission. The signal spectrum is shown in Fig. 6(c). The signal then passes through the regulating amplifier which has two functions. It raises the level of the modulated signal so that it is suitable for demodulation and also provides an output which is eventually used to phase lock the local oscillator. The local oscillator is, of course, used to demodulate the signal as described earlier. These two outputs from the regulating amplifier are stabilized in level and are virtually independent of changes in the input signal of up to ± 6 db. The output from the demodulator, Fig. 6(d), is passed through a 4.75-kc phase corrected low pass video filter and a video de-emphasis network which restores the loss at 2.5 kc as introduced in the sender. The signal so obtained, Fig. 6(e), is then amplified and passed back to the film console for recording as described earlier.

Figures 7 and 8 give some idea of the general appearance of the completed equipment.

Conclusions

The equipment described in this paper has been used on many occasions for the transmission of short lengths of film between the United Kingdom and Canada in both directions. In particular it should be mentioned that it was used extensively

on the occasion of the Queen's visit to Canada in 1959, and also in connection with President Eisenhower's visit to Europe, and Mr. Khrushchev's visit to the United States.

The hour or so which the system takes to transmit a length of film which will normally be on the television screen for about thirty seconds has proved a very convenient unit. It is possible that in some circumstances this system will provide a much cheaper method of exchanging short lengths of film than, for example, the use of normal television transmission and recording systems, although the major benefit of the use of this system at the moment is obviously over very long circuits such as those across the Atlantic and those which will eventually link the British Commonwealth.*

Acknowledgments

The active cooperation of the British General Post Office, the Canadian Overseas Telecommunications Corp. and the American Telephone & Telegraph Co. during the testing of the circuits and equipment is gratefully acknowledged.

In conclusion, we would like to thank the Director of Engineering of the British Broadcasting Corp. for permission to publish this article.

*Features of this system are protected by U. K. Patent Applications Nos. 18277/59, 18853/59 and 16323/59.

Bibliography

1. *Post Office Electrical Engineers Jour., 49:* 1957.
2. A. J. Bennett and E. T. C. Harris, *Post Office Electrical Engineers Jour., 49:* 438, 1957.
3. J. W. Rieke and R. S. Graham, *Bell System Technical Jour., 32:* 915, 1953.

A Damping Device to Improve the Image Sharpness and Steadiness of Prints Made on a Continuous 16mm Motion-Picture Printer

By GERALD M. SEELEY

A simple modification to the gate shoe of a 16mm Bell & Howell Model J Printer is described. A rayon velvet pad is positioned over the printing aperture in such a way that more intimate film to film contact is produced. This also reduces spurious film movements at the aperture.

In recent years, 16mm films have achieved a position of major importance in the field of professional motion pictures. This has come about with their extensive use in television, educational and industrial applications. Along with the increased use of the medium, the need for better quality has also become apparent. One factor that emphasizes print quality is the degree of sharpness and steadiness apparent in the projected image. Modern photographic materials also impose additional demands on the ability of the printing equipment if the improvements in definition and grain characteristics now available are to be fully realized.

With these thoughts in mind, one of the most effective modifications that we have made in one of our 16mm printers is the incorporation of a very simple device, probably costing less than one dollar. In view of some of the problems that have been brought to our attention by the motion-picture industry, we offer this method as a possible aid in producing sharper and steadier prints based upon the experience in our own motion-picture testing laboratory.

Motion-picture films are subjected to many tests after manufacturing. Among these are the practical tests which are designed for the evaluation of picture and sound quality. Here the film is handled much as it would be in the hands of the user. In this way it is possible to study and analyze the behavior of the product under conditions representative of trade practice. It is not within the scope of this paper to discuss film testing techniques, except to show how necessary it is to maintain all equipment used for making such tests in peak operating condition. If this is not done, the final analysis of the results may be at least partially obscured by unwanted variations introduced by malfunction of the equipment used. This discussion will be confined to the printing operation, and in particular to a minor modification made to the gate shoe of a 16mm Model J, Bell & Howell printer (Fig. 1–3).

Contributing Factors

There are a number of conditions that may affect the behavior of the films in a continuous printer. Some of the most common are:

(1) The general mechanical condition of the printer, including alignment of the film transport system and the condition of the sprockets and rollers.

(2) The surface characteristics of both negative and positive films. These may be affected by conditions present in the original or negative process, storage, conditions for both negative and positive films, and the relative humidity of the printing room.

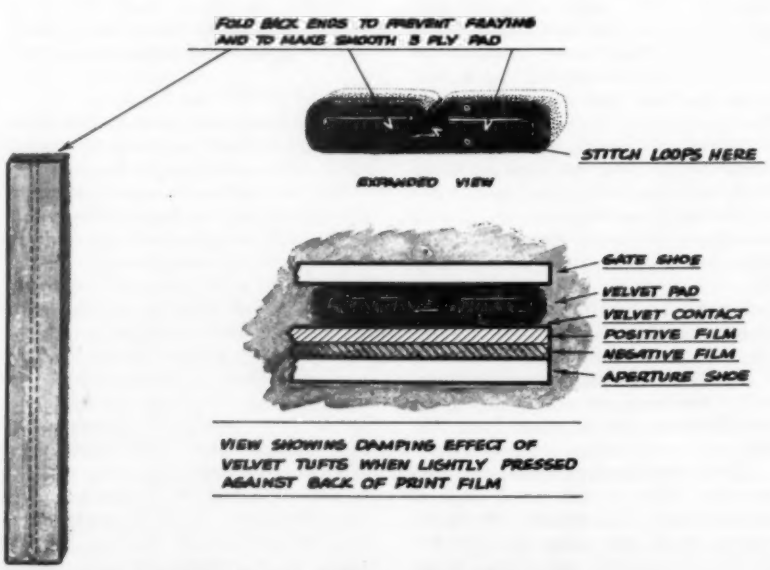

FOLD BACK ENDS TO PREVENT FRAYING AND TO MAKE SMOOTH 3 PLY PAD
STITCH LOOPS HERE
EXPANDED VIEW
GATE SHOE
VELVET PAD
VELVET CONTACT
POSITIVE FILM
NEGATIVE FILM
APERTURE SHOE
VIEW SHOWING DAMPING EFFECT OF VELVET TUFTS WHEN LIGHTLY PRESSED AGAINST BACK OF PRINT FILM

Fig. 1. Construction and placement of velvet gate shoe pad.

Presented on May 11, 1961, at the Society's Convention in Toronto, by G. M. Seeley, Film Testing Div., Eastman Kodak Co., Kodak Park, Rochester 15, N. Y.
(This paper was received on April 21, 1961.)

Fig. 2. Gate shoe in closed position.

(3) The pitch of the negative film and the pitch relationship between the negative and positive films. Some poor pitch relationships are unavoidable. One example is a color duplicating cycle, where a short-pitched original is printed to a short-pitched internegative film.

(4) Variations in the physical dimensions of the films that may approach or exceed the limits of printing tolerance.

Since one or more of these factors may influence printer performance, an ideal solution would be to find some way to increase the tolerance of the printer to these conditions. This is exactly what we are trying to accomplish with the velvet pad on the gate shoe.

Experimental Procedure

It is quite obvious that prints which exhibit sharpness deficiency and excessive motion must be undergoing some kind of disturbance at the printer aperture. To investigate this theory, a piece of folded velvet was held lightly against the back of the positive film, directly over the aperture, while a print was being made from a variable-area sound test negative containing a 3000-cycle track. A check print was made in the normal manner. We should mention at this point that the amplitude-modulation level of a properly exposed print made from such a sound test negative is an excellent indicator of printer behavior in regard to the negative to positive contact and general stability of the films at the printer aperture. The AM level of the sound print provides a numerical evaluation to supplement and verify subjective impressions received when viewing a projected picture image. The results of this crude velvet test were gratifying. The AM level of the check print registered 6.5%, whereas the level of the experimental print dropped to 2.7%.

Tests

On the basis of this experiment, it was decided to explore the idea further by making a pad that could be secured to the gate shoe so that more extensive tests could be made. The pad consisted of a piece of rayon velvet with a nap about $\frac{1}{16}$-in. thick.* This was folded into a pad three layers thick, measuring $\frac{3}{4}$-in. wide and $3\frac{3}{4}$-in. long. It was attached to a conventional gate shoe with Pliobond cement. Due to the extra thickness, it was necessary to adjust the gate shoe so that it remained parallel to the aperture drum. The shoe pressure was adjusted by threading two pieces of film through the feed sprocket, tension rollers and aperture sprocket, leaving the ends free below the aperture sprocket. The shoe pressure was set at the point where the weight of the tension rollers would barely lift the film against the sprocket teeth. This was taken as the point of minimum pressure. Sound tests were run at this level, and also with the pressure increased first by one half turn and then by one full turn of the clearance adjusting screw. Analysis of these tests indicated that the point of minimum pressure was most effective. The AM level at this pressure was slightly over 1%.

The work up to this point was aimed toward improving the quality of sound printing. In view of the encouraging results, tests were then made to determine the effect on picture quality. Picture negatives were selected which would serve as critical test objects for picture sharpness and steadiness characteristics. These tests verified the results of the earlier sound test. Compared to the pictures obtained using the conventional gate, the pictures made using the velvet pad were generally sharper and steadier. Any unsteadiness on the screen was at a lower frequency, and consequently less objectionable.

To further test the stabilizing effect of the velvet pad, samples of print raw stock were selected that had excessive dimensional variation in pitch, margin and width. Four strips of film, one of which was dimensionally excellent and three which exhibited at least one of the variations previously mentioned, were printed from the sound test negative and the test picture negatives using both the conventional gate and the velvet pad gate. The correlation between the sound results and the picture prints was good. An unacceptable AM level was present when the films having excessive dimensional variation were printed using the conventional shoe; but in every case acceptable levels resulted when the velvet pad was used.

* Manufactured by Martin Fabrics Co., 48 W. 38 Street, New York 18.

Fig. 3. Gate shoe in open position.

This test does not necessarily represent situations experienced in the industry, but we felt that the ability of the velvet pad to produce acceptable quality under these adverse conditions would be indicative of the performance that might be expected when other undesirable factors were present.

Theory

We would like to emphasize that little or no difference will be noticed when all printing conditions are ideal. However, ideal situations, for various reasons, are frequently not possible. It has been our experience that, as a general rule, the velvet pad technique will damp spurious film motions in the printer aperture to a degree that the overall continuous quality of the printer output will improve. We theorize that the damping action is brought about when, under light pressure, the tips of the velvet nap are slightly bent in contact with the films. This bending may occur in several directions simultaneously. A bracing effect is thus created which resists any tendency of the film to change position. In this manner, the films are pressed into intimate contact and at the same time short term lateral and vertical motion is retarded.

Practical Application

As a result of the satisfactory performance in these preliminary tests, the velvet pad was accepted as the standard setup on this printer for both sound and picture work. Well over 100,000 ft of film was printed with the original pad before it was changed. At that time, it had become soiled but showed very little wear and was still effective. Some concern had been felt at the outset of the project that dirt might accumulate in the velvet and produce scratches; however, over a period of about $1\frac{1}{2}$ years of operation

with probably over ¾ of a million feet of film printed, no problems of this type have occurred. There has also been little evidence of wear on the printer aperture during this period. This is probably due to the extremely low pressure applied through the velvet nap. Furthermore, the printer lamphouse is slightly pressurized at about 6 psi. The escaping air at the aperture tends to counteract any additional pressure on the aperture. This theory is supported, to a degree, by the findings of Ott and Lovick† regarding internal air jets. Obviously, gross alignment and film transport adjustment errors will not be overcome by the use of the velvet pad. Our experience to date, however, indicates that at least the effects of some of the conditions that can cause unsteadiness and lack of sharpness in the printed film will be minimized.

†Howard F. Ott and Robert C. Lovick, "Internally directed air to improve contact and negative life in continuous motion-picture printers," *Jour. SMPTE* 66: 109–11, Mar. 1957.

Summary

The results from the use of the velvet pad on our printer may be summarized as follows.

(1) There is an improvement in image sharpness and a slight increase in apparent contrast of the print. This is particularly noticeable when printing conditions are less than ideal.

(2) The steadiness of the image on the screen has been improved.

(3) The quality of sound prints has improved due to a significant reduction in amplitude modulation.

(4) There has been a definite reduction in printer maintenance and downtime because time is no longer wasted in trying to locate vague and improbable printer troubles.

Note

The Convention presentation was concluded with a short demonstration film illustrating some of the typical results obtained using the velvet pad. This film consisted of prints made with a conventional gate and with a velvet pad gate. The prints made by each method had been interspliced three times in each scene to provide an opportunity for comparison.

The first scene was from a grid negative. This print was an overlay exposure of two synchronized passes of the same negative. The stability of the films in the printer gate was indicated by the accuracy with which the images from the first and second exposures coincided.

In the second scene, the degree of sharpness of the fine detail was a measure of the contact between the negative and positive films.

The color print in the final scene demonstrated the familiar effect, sometimes encountered on a continuous printer, when poor pitch relationship is present between the negative and positive films. The difference in sharpness and steadiness between the conventional and velvet pad sections was shown as a measure of the control exerted by the velvet pad in this situation.

A Constant-Time, Variable-Intensity Microsecond Exposure Sensitometer

By FRANK P. HERRNFELD

The constant-time, variable-intensity sensitometer was designed for investigating the response of photographic film in the microsecond exposure region. The fastest time available is 1.5 μsec with 2 w/sec of energy per flash. Exposure times of 15 and 150 μsec at identical energy level per flash are also available.

THE CONSTANT-TIME, variable-intensity sensitometer (Fig. 1) features a straight platen which allows the operator to make an exposure in the center of a 22-in. wide film or paper. The standard exposure aperture is 35 by 210 or 10 by 210 mm. The exposure is made through a photographic or carbon deposit step wedge. A knob on the front panel gives the choice of three different exposure times. Provisions are made to introduce color filters.

Electrical Features

The electrical schematic is shown in Fig. 2. The system is conventional except for the manner in which the duration of the flash is modified without changing its light energy. The time of discharge t is determined by the resistance of the arc R_a, any external resistance present R_E, and the capacity of the condenser C. Mathematically this is expressed as:

$$t = (R_a + R_E)C \qquad (1)$$

where t = time in seconds, R = resistance in ohms, and C = capacitance in farads.

In position 1, i.e. the 1.5-μsec flash duration, the flash tube is placed directly across the 1-μf capacitor C_1. In position 2, the flashtube is placed through resistance R_{E_1}, about 2.3 times greater than that of the arc across the combined capacitances of C_1 and C_2. From Eq. (1), it is evident that in position 2 the time of discharge was increased to ten times that of position 1. Even though energy stored in the position 2 capacitor is three times that stored in the capacitor of position 1, two thirds of the energy is absorbed by the added resistance. In position 3, the

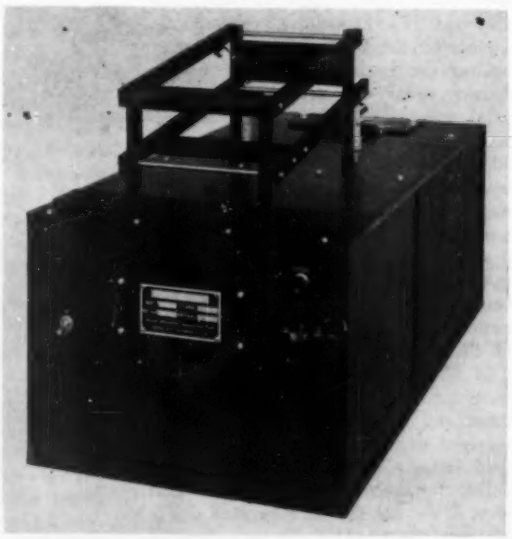


Fig. 1. The constant-time, variable-intensity sensitometer.

Presented on May 11, 1961, at the Society's Convention in Toronto by Frank P. Herrnfeld, Frank Herrnfeld Engineering Corp., 5716 Camille Ave., Culver City, Calif.
(This paper was received on April 19, 1961.)

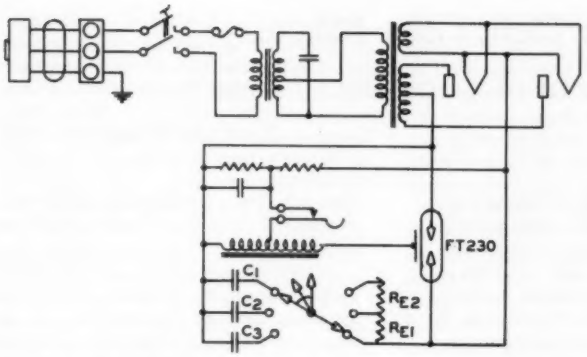


Fig. 2. Electrical schematic.

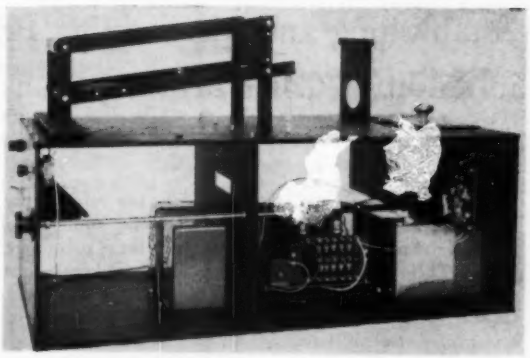


Fig. 3. Interior construction.

resistance R_E is increased to nine times the resistance of the arc, and a third capacitor is added to bring the total capacitance to 10 μf. Thus, the time of discharge is increased to 100 times that of position 1, again without changing the total energy reaching the flashtube.

Another point of interest in the electrical circuit is the manufacturing technique of the discharge condensers. Many of the nationally known brands of condensers were tried and rejected because of "ringing." This "ringing" is an oscillation caused by the inductance of a "noninductive" capacitor in resonance with its capacity and excited by the negative resistance of the arc. We finally discussed the problem with Elpac* which was willing to supply the special units required in the modest quantity required. The capacitors were wound with the two aluminum foils extending outside the insulating material on opposite sides of the windings; then the aluminum ends were welded together. This design, combined with the use of short, heavy leads, made the unit practical.

Light Source

As a light source, the GE FT-230 short gap flash-tube was chosen. Unlike standard flashtubes which use a mixture of gases, the FT-230 is filled with xenon gas only. The spectral energy distribution of this tube is continuous, except for a few superimposed higher intensity lines. Energy is cut off at approximately 300 mμ due to the glass envelope. Maximum light output lies between 418 and 440 mμ. The spectral distribution will have to be altered by color correction filters when the sensitometer is used to expose color film of tungsten light rating. The efficiency of the tube is approximately 10 lm/w in the circuit used. This tube has an arc length of only 3 mm. The shape of the arc is approximately spherical, with a diameter of about 8 mm the way the tube is loaded in the sensitometer.

To provide trigger energy and reliable flashing, a separate trigger electrode in the form of a split cylinder is used.

Mechanical Features

The inside construction of the unit is shown in Fig. 3. The flashtube is mounted in the rear compartment. The front plate of the rear compartment is used as the first light baffle. Another baffle is located halfway between the flashtube and film. Mounted to the front plate at 45° is a first surfaced aluminized silicon monoxide overcoated mirror which also acts as the third and last light baffle. The filter holder is shown removed from its slot so as not to obscure the view of the hole in the first baffle. The step wedge is located below the film sample to be exposed.

The distance between the flashtube and the center of the film aperture is 520 mm. The fall-off in light intensity due to the flat platen construction is thus held to less than 0.01 log E from center to either end of the 21-cm aperture.

Conclusion

An advantage of a flashtube type of sensitometer is its capability to give extremely short exposure times with virtually no change in intensity or color of light with time. A regulated power supply assures reproducible results. Light energy is held constant for the 1.5-, 15- and 150-μsec exposures. The intensity is sufficient to test both slow emulsions such as color print film, and fast emulsions such as panchromatic films.

After an initial warm-up of two minutes, a charging time of three sec should be allowed between flashes. Line voltage variations from 90 to 135 v will not affect the light output. 100,000 flashes in any one of the three positions reduced the light output by less than 10%.

* Elpac, Inc., 4270 Artesia St., Fullerton, Calif.

Establishing and Maintaining Printer Light Color Balance in Additive Color Printing by a System of Controlled Chance

By PABLO TABERNERO

The problem treated in this paper does not refer to the process of timing color negatives, but to the necessity of maintaining uniform color quality from print to print. A definite color balance for a given set of printing conditions must be established. This balance will often depend on unknown quantities such as shifts in relative color sensitivity of print materials from one emulsion number to another. General stability conditions of an additive printing process are mentioned. A system of controlled chance is defined. Essentials of the system proposed are enumerated and described. Some mathematical reasons for the selection of an adequate number and sequence of possible printer-light trial combinations are discussed. Economic considerations are discussed briefly.

General Considerations

The problem considered in this paper is not that of color timing of a number of scenes to find the correct color printing balance for each individual scene and the correct overall balance for an entire sequence. Methods of doing this have been given by different authors,[1–9] and need not be repeated here. These methods apply to subtractive as well as additive color printing systems, so that from this point of view, nothing remains to be said. The problem to be considered, is that of making a series of prints with consistent uniformity with respect to color balance, and also, of finding the appropriate color balance of the printer light for a given set of printing conditions when using an additive printing method. This means that we must find the corresponding color balance of the printer light for a given set of filters, for a given combination of negative and print stock, and for a specific set of processing conditions—all this under practical working conditions with a minimum loss of time and material. In short, a given color negative should, under all circumstances, give the same color reproduction in the print made therefrom.

Some general comments may be made in relation to the foregoing statements. First, the timing problem and the establishment of the color balance of the printer light are related problems and similar methods may be applied to both. Also, the initial color timing of each individual scene depends on the specific color balance of the printer light, which we might call its *basic color balance*. But there the similarity ends since, after making a number of prints, we may find some unknown conditions—as a result of aging, or subsequent installation of a new printer lamp, or by the use of a different emulsion number of print stock. The latter may have a different relative color sensitivity for the three layers and require a different filter pack.

Secondly, for timing as well as for general balancing purposes, some test object must be used. This will generally be a gray scale or gray patch where the color accepted visually as gray (normal or neutral) may not be an actual spectrophotometric gray, but may be any conventional and convenient color which serves the purpose given.[2] It may, of course, be not too far away from a nonselective gray. The question which immediately arises here is how to produce the necessary test objects. They may be produced during the actual shooting of a scene where the camera crew may photograph short lengths of a gray and color scale. Or, the laboratory that processes the film may produce it's own standard test negative, filming a standard gray and color scale under standard conditions of exposure. Both systems of making a test object have their advantages and disadvantages.

Producing such a test object in the studio has the advantage that it can be placed on the original negative stock and supposedly under the same exposure conditions as the corresponding scene itself. The disadvantage of this system is precisely that we are forced to use the word *supposedly*, since it may be impossible to photograph the gray scale under exactly the same exposure conditions. The intensity and color of the light may have changed between the shot of the test card and of the scene, especially on location; or there may be slight differences in the angular position of the test card which may account for noticeable differences in it's reproduction relative to that of the scene—depending on the color, intensity and position of the lights illuminating the scene, and reflections from scene elements. There may also exist color effects in the scene, which may preclude the use of a standard test card. There is no standard gray card to be used by everybody for color testing purposes. It is questionable, therefore, whether a test negative made in the studio, will meet the necessary conditions of accuracy under all circumstances.

A test negative made in the laboratory certainly meets the conditions of standard exposure and of repeatability of the exposure conditions. Also, the condition of equality of raw stock for the test negative and the corresponding picture is easily met. However, differences in quality of illumination and exposure level which may exist between different scenes cannot be taken into account when making a test negative in the laboratory. This is a definite disadvantage for timing purposes; but for the purpose of matching a set of prints, or for matching the various reels of the same release print by incorporating suitable lengths of the test negative into each reel of a feature, a test negative made by the laboratory under stringently controlled conditions is quite suitable. Also, the laboratory that processes different kinds of color stock, will find great advantages in making a suitable test object for each stock and process.

Of the two systems of producing a test object, the one made in the studio would probably be the most suited for timing purposes, especially for automatic or instrumental timing. However, the test negative produced by the laboratory is practically indispensable for matching release prints for color balance. In either case, the test object must contain a gray scale suitable for densitometry. Also, it is desirable, but not mandatory, that it contain a short scale of the fundamental colors R,G,B and Y,M,C. If it contains normal flesh tones, this also will help. Full conditions for the test negative will be given later in the text.

After this brief discussion of the conditions the test negatives must meet for these purposes, let us now return to the main problem: What shift in printer light color balance will be necessary to compensate for shifts in the relative color sensitivity of different coatings of the same print stock. It may become necessary to print the same color negative successively with different types of print stock. Different types of negative stock may also have to be printed on the same print film and if different negative printing characteristics exist they make it entirely impossible to prejudge the printer light color balance necessary to yield a normal print. Such conditions may be found in the duplication process with certain types of material. Here the

Presented on May 4, 1959, at the Society's Convention in Miami Beach by Pablo Tabernero, Laboratorios Alex S.A., Dragones 2250, Buenos Aires, Argentina.
(Final manuscript received May 29, 1961.)

negative has an entirely different visual appearance from that of its duplicate negative, even though they result in practically identical prints with the same printer light color balance when they are properly made. In such cases it must be assumed that nothing is previously known as to the characteristics of the print stock and how it will "see" the three component colors of a given color negative. This is also the situation when first establishing a new color process in a laboratory and no previous experience exists, i.e. when the basic color balance of the printer light is to be established for the first time. In short, our problem is that frequently we will have to deal with a certain number of unknown entities.

In this case, and particularly if a laboratory is currently using various color processes, it will usually be easier to use some systematic trial-and-error procedure than to try to calculate printing conditions anew for each case from some theoretical values. Finding or establishing new parameters for each case will generally take the same time as a trial-and-error procedure and will yield no better approximation, in the first try, than the latter. Also, under practical working conditions we may find such differences between print stocks as to oblige us to constantly revise our calculations. It cannot be denied that a purely mathematical and well-founded procedure for establishing a a printer light color balance may have great value, especially for a laboratory working with only one color process and for the case where variations in relative print stock color sensitivity are known in advance. Under all other conditions, a trial-and-error procedure is practically a "must," and it is this aspect with which this paper is concerned.

Before discussing the details of establishing a test procedure for additive color printing, it should be mentioned that all other conditions such as processing conditions, lamp current, printing filters, their selection and permanency, etc., must be kept as constant as possible, and no pains in this respect should be omitted if consistent results are desired.

Here some special comments about the R,G,B filters for additive color printing will be in order. It is of utmost importance that these filters be the most stable ones which can be found. Experience demonstrates that the most suitable filters for the purpose are glass ones. Their stability under the temperature conditions of an additive printer is far greater than that of other types such as gelatin or interference filters. While earlier authors have questioned the stability and workability of glass filters,[9] it is now established that they are the most stable, permanent and practical filters for the purpose of additive color printing.[10] Gelatin filters will fade rapidly under the prevailing heat of an additive printer. Interference filters, which possess the advantage that they can be engineered to specifications, will not, in many cases, withstand the heat conditions of an additive printer without changes in their spectral transmission characteristics. Glass filters, such as these produced by Corning Glass or by Schott and Genossen, will yield quite consistent results. The only necessary precaution is that one must allow sufficient warm-up time before starting printing operations or taking photometric readings.

The test procedure to be described can be applied successfully to any one set of established printing and processing conditions. But if one or several of these conditions are altered, if, for instance, a different set of R,G,B filters is used or development conditions are changed, results will not be comparable and the test procedure has to be repeated.

Some Basic Definitions

Color terms used. The terminology used in this paper will correspond to that used by Judd,[11] that is, the terms will apply to the subjective appearance or observer perception of the color attributes of any given printer light or printer light combination as projected upon a pure white translucent material situated as the printer gate.

Color: that perceived at the printing gate, including achromatic as well as chromatic colors.

Hue: the red, green, blue, cyan, magenta or yellow appearance of a color and corresponding intermediates.

Saturation: that white content of the perceived color (which defines the gray content of the print color obtained from it).

Achromatic Color: color without a hue, that is, white or gray.

Chromatic Color: color with a hue, that is, for all colors, except white or shades of gray.

Brightness: the attribute of the color perceived that varies from dim to very bright, and whose degree of brightness is compared with a standard brightness value of an achromatic (white) color perception.

The Normal System. For the purposes of our discussion we shall define a *normal system* as an additive color printing system where equal numerical printer light values for R,G,B and the corresponding photometric brightness values for the *standard observer* will yield an achromatic color of the printer light combination of all three, it's brightness depending on the brightness of the component colors, and where the relative color sensitivity of the print material is the exact inverse of the integral R,G,B densities of the gray scale test object on a color negative.

These assumptions do not hold for most of the printing conditions found in practice. They help, however, to simplify the discussion of our subject and constitute what we might call the ideal case. As for the correspondence of photometric values for like numerical printer light values for R,G,B this condition is almost never fulfilled exactly; but this fact is of no consequence for the test procedure under discussion since relative photometric values are sufficient for the purpose, and calculations can be entirely confined to the relations existing between printer light numbers only.

Central and Non-Centric Neutral Balance. In the normal system, the point for neutral balance, i.e. for a white aspect of the printer light and the corresponding gray or neutral color in the print, will fall, as we shall later see in detail, exactly at the center of a trilinear plot, such as that of Fig. 1. This then could be called a *central neutral balance.* Practically, however, we will find that the printer light color which produces a neutral color in the print will not be an achromatic color because of certain peculiarities of the negative-positive reproduction system. As a consequence of this, there is a need to depart somewhat from our specification of the normal system. This may happen for various reasons; perhaps the print stock does not produce exactly complementary colors or exactly inverse color densities, perhaps the negative distorts the gray condition of the test card, or any similar situation or combination of situations may exist. In all cases where, for a given combination of negative and print stock, the neutral gray scale in the print is produced by a printer light color which, instead of being achromatic, has a definite hue and a more or less accentuated degree of saturation (i.e. by a chromatic color whose corresponding plotting point thus falls outside of the center of a trilinear plot), we may thus speak of an *non-Centric neutral balance* of an additive printer. As already stated this is generally the situation to be found.

The System of Controlled Chance. Chance is the happening of an event which may occur in several different ways. If we know the number of ways in which the event may occur, we may calculate the probability of it's happening. If the several ways in which the event may happen are mutually exclusive (that is, if the event happens in one way it cannot happen in any other way), and if we are in a position to select (or to "bet" on) the way, or several ways, we judge it will happen, then we may have some degree of control over the chance. This may be illustrated as follows. If we have 9 white balls and 1 black ball in an enclosure,

and we are permitted to take one or more balls out of it, we may control the chance for the appearance of the black ball by the number of balls we take out simultaneously. Obviously, if we take the ten balls out together, we are 100% sure that the black ball will be amongst them. It can be shown that the greater the number of balls taken out simultaneously, the greater will be the degree of control over the chance for the appearance of the black ball.

We shall therefore define the *system of controlled chance* as the systematic selection of a restricted number of possible cases out of the total number of possible cases for the appearance of a mutually exclusive event. The number of selected cases and the interval or space between them is so selected as to give the greatest probability for the happening of the event within the boundaries of a comparatively small number of tries.

This is applicable to the situation we find in additive color printing. We may calculate the number of chromatic colors which our printer is capable of producing. We can also establish in how many ways a neutral or achromatic color can be produced. The sum of the two gives the number of all possible colors. From these cases we select, in printing a test series, a restricted number of colors. This test series must thus be so selected as to give us the greatest value for the probability of the appearance of an achromatic color. Within the boundaries of the normal system, the appearance of the achromatic printer light combination will correspond to the appearance of the neutral gray within the printed test series.

Some comments are in order here. The condition of mutual exclusion is fulfilled in additive color printing, since the achromatic color can only be produced in a certain number of ways, and in no others. The greatest convenient value for the probability of the appearance of an achromatic color depends on economic considerations. The more balls we take out of the previously mentioned enclosure, the greater the test series we print, the greater the degree of certainity for the appearance of the black ball (the achromatic color), but the higher will be the cost of the procedure. In additive printing, furthermore, the spacing of the selected test cases is of primary importance since we must select such a series of printer light combinations as to cover an adequate part of the whole gamut of colors which the printer is capable of producing.

Essential Equipment

As stated earlier, we shall need a *Test Object* or test negative. This should be a color negative made on the same type of stock and, if possible, the same emulsion number as the picture negative for which the color balance is to be established. It should be produced by photographing with a normal camera operating at normal speed, and with a lens suitable for color photography, a neutral gray scale, illuminated with tungsten light of 3200 K. It should have a normal density range and the gray patches should be distributed in such a way and be of such a size as to be suitable for densitometric evaluation of their respective areas. It should include selected color patches of R,G,B and Y,M,C and if possible, some flesh tones.

A Printer Photometer and associated means for measuring separately, under the exact printing conditions and with a reasonable degree of precision and repeatability the R,G,B components of any one given printer light combination. For this system it will be sufficient if the photometric values obtained are only relative ones; that is, it will not be necessary to know the absolute values of illumination values in foot-candles. A barrier layer type of photocell is adequate, together with a suitable support which assures repeatability of the position of the photocell. It suffices to have photometric values on an arbitrary scale as long as the instrument gives reasonably constant measurements. If a calibration curve for the printer can be made, like the one suggested by Finney and Weller,[7] this may be helpful, but it is not obligatory.

A Printer Light Level Correction Device by which the individual photometric values of the R,G,B components may be altered independently and at will. This allows for variation of the relative R,G,B balance for any given printer light combination.

A Printer Light Information Storage Device, which will repeat automatically a given sequence of previously established printer light combinations, as represented by the test series, as often as necessary. (If no such device can be used and light changes are to be made by hand, the system becomes too cumbersome and costly.)

A Rapid Light Change Device, preferably automatic, which will permit short lengths of print stock to be exposed through the test negative, while systematically varying color balance in accordance with the test series. Certain types of printers which permit one to change automatically the printer light combination after each two or three successive frames will be particularly well suited for the purpose. In other types of printers, the shortest possible interval between light changes must be used to keep the system within economical limits.

Means for Evaluating the test print.

Operation of the System

General Description. It is relatively easy to locate the neutral point for any given combination of color negative and print stock. First, a preliminary printer setup is made. This consists in selecting a numerically equal printer light combination at a suitable position on the printer light scale so as to get a test print of about normal density. This printer light combination we shall call the *standard combination*. Let us assume it to be R = 25, G = 25, B = 25. Next the color balance of this combination is adjusted in one of two ways: (1) If nothing is known about the process under consideration, the brightness of the three individual components may be so adjusted as to obtain a pure white on a sheet of a pure white translucent material, located at the printing gate. Photometric readings of the R,G,B components are taken for future reference: (2) If something is known about the color process in question, say the standard average photometric values of the combination for a previous series of prints, then these values are given to the R,G,B components. This first adjustment of color balance of the printer does not have to be an extremely precise one.

The next step consists in printing the first test series and evaluating it after processing. The details concerning structure of the test series and the evaluation of the test print will be given below. For the moment we shall consider only the working steps of the system.

If the developed test print shows a neutral color for the standard combination, nothing else remains to be done and after a suitable adjustment for density, we can proceed with printing. If the test print shows a neutral color for any other than the standard combination, as will generally be the case, the next step consists in first measuring with the highest degree of precision the photometric values of the R,G,B components of the particular combination that produced a neutral color in the print and then assigning these values to the standard combination. If no neutral color is shown by any frames of the test series, we then select the combination which gave the nearest approach to a neutral or normal condition, measure the values of the printer light combination which corresponded to it and assign these values as the standard combination.

After this, a new test series is printed, possibly with a series whose values are spaced closer to each other, so that, instead of having "coarse" variations, we now have "medium" ones. Again the neutral test result or its approximation is selected and again, if necessary, the photometric values of the standard combination are changed or corrected accordingly.

A final series may be needed in which a series of "fine" variations are used. From this last series, the final value

may be found. The final adjustment is then made for the standard combination as before, and we are ready for printing.

Our experience shows that once the system is well understood and applied, very seldom will more than two test prints be necessary.

We shall now discuss the structure of the test series, the methods of evaluating the test prints, the relationship of overall density versus color adjustments, and the significance of the adjustment of the standard combination.

The Structure of the Test Series. The easiest way, but certainly not the only possible one, is to select three or four equally spaced printer lights in each of the three series R,G,B and to form all possible combinations between them. If our standard combination is 25–25–25, we could, for instance, select light 25 ± 4. We would then get in each of the series R,G,B, lights 21–25–29, and we would find that, all together, there exist then 27 possible printer light combinations. It is obvious that all of these combinations must be clustered in some way around the standard combination. How close these printer light combinations are clustered about the central point depends, obviously, on the proximity of these light values to those of the standard combination. Had we selected instead, light 25 ± 8, that is light 17–25–33, the 27 different printer light combinations would still encompass the same color gamut and would be centered around the same central point, but would give a "coarse" series, as compared with the earlier one. The center would still be determined by the standard combination, but the test combinations would be spaced farther away from it. Light 25 ± 2, lights 23–25–27 will give a "fine" series under the same conditions.

By selecting an adequate number of test combinations and an adequate interval between the printer lights with which we form them, we may fulfill the condition asked for by the system of controlled chance, namely that the interval between the selected test cases must be such as to give the greatest value for the probability of the appearance of the achromatic, the neutral color, within a minimum number of test tries.

The Evaluation of the Test Print. Evaluation of the test print may be made visually or densitometrically. We have found it very easy to obtain consistent results for uniformity of color balance within a series of successive release prints. Some of these prints were made several months after the first ones, based only on visual comparison with a neutral or standard print of our test object. The eye can easily discriminate minute differences of hue and saturation. Densitometric evaluation of the integral color densities of the test print is, of course, possible; but, it may result in different numerical values for different kinds of color processes when the results appear to be the same visually. Thus the values obtained by densitometric measurement must always be considered in conjunction with the specific process under examination. Also, color densities and their values plotted on a trilinear graph do not coincide with values determined by visual methods, and thus may be only of a relative value. Within these limitations, however, densitometry of the test print may be a very helpful complement to the visual judgement of the same.

Overall Print Density vs. Color Adjustments. The system described here primarily takes color changes into account but it does permit one to compensate for overall print density differences. This compensation may be easily made simultaneously with the color adjustment of the standard combination. This may be accomplished by either adding or subtracting the necessary number of printer lights or their photometric equivalents to or from each of the three photometric values which have given us the neutral color in the test print — that is, which have produced the desired color, its hue and saturation, but with too low or high a print density. Almost everybody in a laboratory is able to translate density differences of a print correctly into the light values necessary for their compensation. In additive printing we have the very important advantage that equal proportional changes of the brightness values of the R,G,B components (that is, equal changes in printer light value) will readily produce a change in overall density without altering color in a perceptible way if the correction to apply does not exceed a few printer lights, say four up or down. If the overall intensity correction is rather great — we may come upon a print stock of a slower than expected speed — it will be better to adjust first the photometric values of the standard combination as necessity dictates, run a new test series with the same color balance as the first one, and from the results of this last test, proceed to color correction.

Effect of Adjustment of Color Balance of the Standard Combination. Adjusting the photometric values of the standard combination amounts to a shift of the whole color range of the printer. If, for instance, we find that we must subtract three printer light units from the B component because we have found too much yellow on our test print, dividing thereby the photometric value by a fixed amount; each single printer light of the whole B series will thereby be divided by the same amount, and every one of all possible printer light combinations where B takes part will also have a proportionally lesser brightness value in blue content. Expressed in the terms of our earlier definitions, all this amounts to the following. When first adjusting our printer so as to obtain a white light (a pure achromatic color) at the printing gate, we have made an adjustment as for a normal system. If now the standard combination fails to produce a neutral color in the test print, which, however, is produced by some other combination of the test series whose corresponding color point plots away from the center of the trilinear plot (which we may take to represent all possible colors the printer is capable of producing), we have then a *non-centric neutral color balance.*

Now, in assigning to the standard combination the photometric values of that combination which, while being of a chromatic color, produces the neutral color in the print, the new color central point is not placed into the center of the system, but rather the whole system is shifted so as to center around the translated neutral point. We depart thus from the normal system and obtain a *compensating system*, one which tends to compensate for differences in color balance of the color process at hand.

Selecting Adequate Number and Sequence of Trial Combinations

When calculating a system of controlled chance for testing purposes within an additive color printing system, we must first find out the number of all possible colors the printer is capable of producing, and then we must select an adequate number and sequence of test combinations. Space will not permit us to go into the detailed mathematics involved in this, so I shall merely try to enumerate the more important facts, and to illustrate them with some graphs.

The first fact is that the number of all possible printer light combinations of an additive printer, as well as those possible within any series of equally spaced successive printer lights we may select for testing purposes, equals the cube of the number of printer lights at hand. Three printer lights in each of the R,G,B series will permit us a maxiumm of 27 combinations; 40 printer lights, a maximum of 64,000.

The next fact is that reckoning within such a great quantity of possible cases is made much easier by some kind of graphical representation. Here we can advantageously apply a trilinear plot such as mentioned for similar purposes by Evans, Hanson and Brewer.[12] After subtracting from each printer light combination, that is from each of its

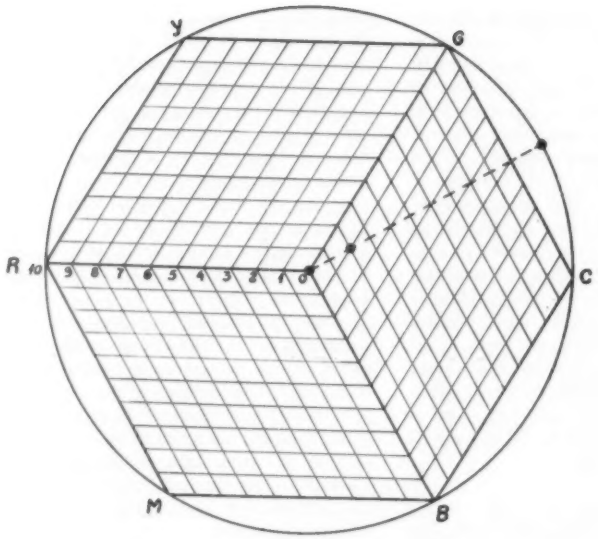


Fig. 1. Trilinear representation of a series of additive printer light combinations: $n = 11, r = 10$.

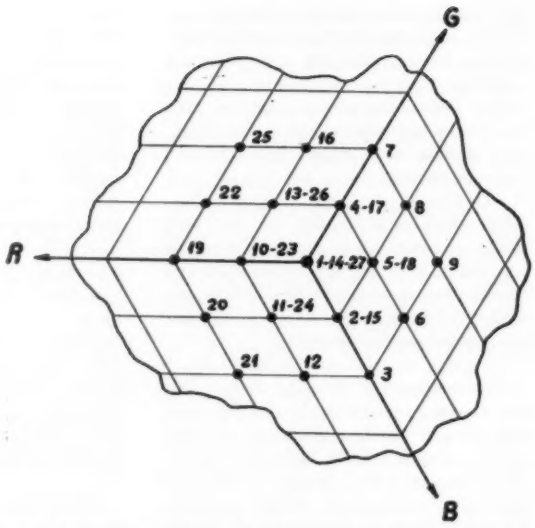


Fig. 2. Location of points of equal color but different brightness for a series of printer light combinations obtainable with $n = 3$ printer lights: $r = 2$.

three components values, the lowest one, we will find two remaining values or residual differences which serve as ordinates for the corresponding *Color Point*. Figure 1 represents such a point for the values Green = 2, Blue = 1. In the normal system, a line drawn through the point of origin and through the color point and projecting it onto the outer circle will give us some measure of the printer light hue obtained, a hue between cyan and green in our example. The distance between color point and origin may be taken as a measure of the degree of saturation of this printer light color and the gray content of the corresponding print color. Within such a graph we may define as *neutral point* any color point, non-centric or central, which produces the neutral print color.

Going one step further, we may now establish the *color range* of a series of printer lights, which we define as the greatest possible residual difference which can be obtained within this series. All the printer light combinations which contain the maximal residual difference will fall onto the outermost concentric hexagon of the graph representing the series. This is the limit of all possible colors we may obtain with the series. All colors produced by printer light combinations which yield smaller residual differences must fall within the limits of this color range.

When such a graph is examined closely for a given series, we will find that the number of differentiable colors that can be produced with the series is considerably smaller than the totality of printer light combinations that can be made. We will also find that many colors are repeated a certain number of times at different brightness levels. Consider Fig. 2. Here we have a series of 27 combinations, the cube of 3. At the center we find three superposed white colors, on the first concentric hexagon we find 6 pairs of like colors, and on the next and last hexagon we find 12 single different colors. We have only 19 different colors, the maximum number obtainable within the color range of a series of three printer lights each for R,G,B. May it be mentioned briefly that within the maximum color range of a given series of printer lights we may find and define a series of partial color ranges in a number equal to the number of printer lights itself.

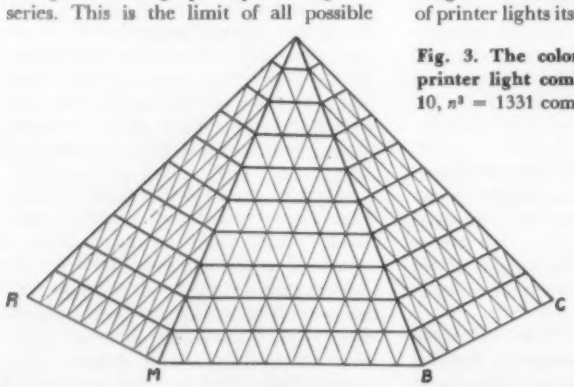


Fig. 3. The color pyramid of additive printer light combinations: $n = 11, r = 10, n^3 = 1331$ combinations.

From the foregoing it follows that the true representation of all the colors and corresponding printer light combinations of any given series of printer lights is a hexagonal pyramid such as that in Fig. 3. The height of this pyramid represents the maximum number of achromatic printer light combinations that may be obtained within the series. The base of the pyramid represents the maximal color range, and hence, the maximum number of colors obtainable.

Knowing the number of colors and their location we now have the elements with which to construct a test series. The series may be constructed in several ways and in any desired sequential order. The principal conditions it must fulfill are the following. It should include a partial color range of the printer great enough to contain the neutral point which, as already stated, may not be central. It should be at such a printer light level as to yield approximately normal print densities. It should provide us with a sufficient quantity of test points within the color grid to give the greatest probability for finding the neutral point, but with no excess of test points.

One of the easiest ways to construct a test series, but by no means the only one possible, is perhaps the n'^3 series where n' is the number of equal printer lights selected in each of the R,G,B series. Figure 4 represents such a series for $n' = 3$. The "spread" (the printer light interval chosen) of this series is, as can be seen from the figure, equal to 4. The outermost hexagon of such a series is what determines the partial color range of the printer explored by the test series.

The limiting factors of such a series are the following. The number of printer light test combinations increase with

the cube of n', what amounts to rapidly increasing lengths of film used for testing purposes. The spread of the series must be great enough to explore an adequate portion of the printer's maximal color range, but it must not be so great as to have the test points too widely distributed over the color grid, thereby diminishing the chance of coinciding or approximating the neutral point. The series must include a sufficient number of test points so as to reduce the necessity of repetitions to a minimum.

Obviously, the greater the number of test points, the greater will be the probability for coinciding one of these with the neutral point. But what will our probabilities for finding it really be? There exist, at a first glance, two important possibilities; that the neutral point falls inside or outside of the explored partial range. But there also exist two very favorable factors. (1) The neutral point, while almost always out of center, will almost never fall very far away from the center of the normal system; therefore we will find it almost always within a test series-net, restricted to the central part of the printer's maximal color range. (2) Independent of where the neutral point falls, even if it falls outside of the explored color range, we can easily judge, by inspection and evaluation of the test print, in which general direction we have to shift the color balance of the standard combination before printing a new test series, and where, with increased probability, the neutral point will fall within the explored range. We are, thus, in a better position than the man who takes the white balls out of an enclosure, trying to find the black one, since our — figuratively speaking — white balls tell us where to look for the black one. These two facts efficiently contribute to making the effective probability of finding the neutral point far greater than could be concluded from a simple consideration of the purely mathematical probabilities.

As for these, the mathematical probabilities are easily established. Of a special interest are: (a) the probability for finding the neutral point in case it is included in the partial color range explored; (b) the probability for the neutral point falling within or without the explored range; and (c) the overall probability for finding the neutral point as a result of the combined two probabilities previously mentioned. Formulas for these probabilities are readily found and may serve as a useful guide when constructing a test series.

Finally, Fig. 5 may serve to illustrate what happens when the neutral point falls outside of the explored partial color range. Suppose our starting point is S, the central point of a normal system, and N is the non-centric neutral point whose location we are striving to find.

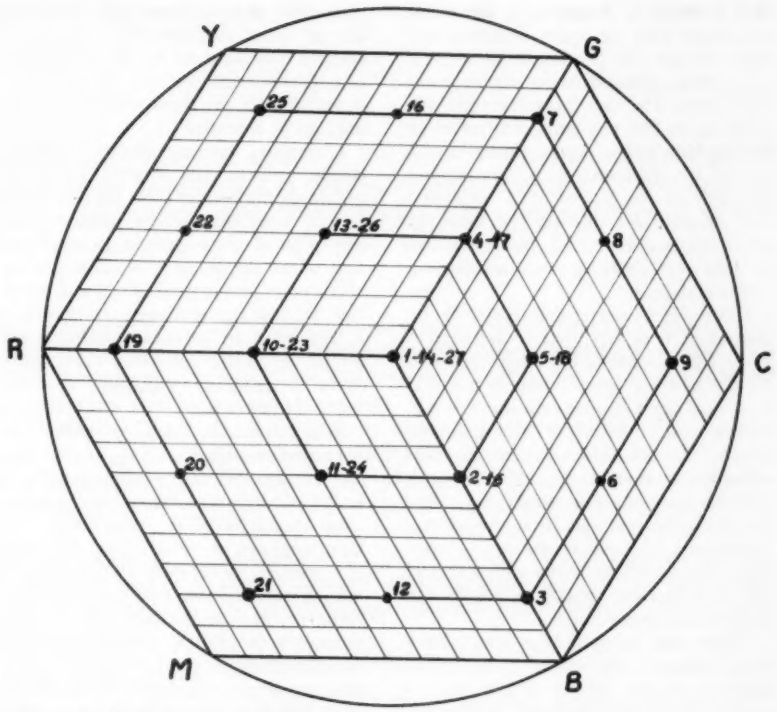


Fig. 4. Graphical representation of a n'^3 test series: $n' = 3$, *spread* $= 4$.

We first print an n'^3 test series with a spread of 4, centered around S. Inspection of the test print will indicate that the color of the test print which comes closest to the neutral or standard color will correspond to a printer light color which will plot at point T. The hue of point T (orange–red), as can be seen by the angular relations, will be that printer light hue of the first test series which comes closest to the hue of point N. Of the two identical hues of this color which appear in the first test series, the one corresponding to point T comes also closest to point N with respect to its saturation (distance from the center).

The second test series, with a spread of 2, will thus be centered around T by adjusting correspondingly the photometric values of the standard combination. This time, by inspection of the test print, we will find U to fall closest to the printer light hue asked for as shown by their angular relation. A second adjustment of the standard combination, and the printing of a series of spread 1 centered around U, will yield one printer light combination which coincides with N. We have thus arrived at the value asked for, and are ready to print.

All this sounds more complicated

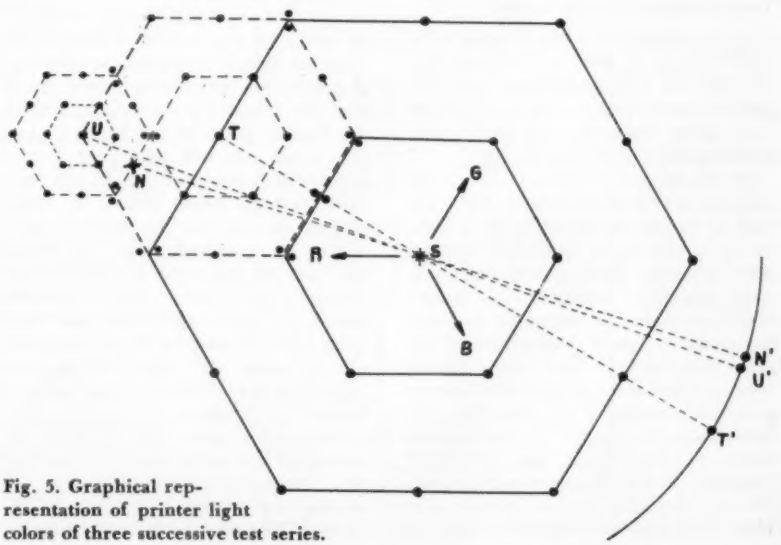


Fig. 5. Graphical representation of printer light colors of three successive test series.

than it really is. Analyzing a procedure on paper may be quite cumbersome, even though the procedure as such is very easily executed in an almost automatic way. The first thing everyone will seek out on the test print will certainly be the hue which comes closest to the hue of the standard color. The second step will be the judgment of saturation and density. All this can be done by measuring and reasoning, but it also can be done very easily by visual comparison with a standard.

From the foregoing description of the procedure it is seen that if the neutral point falls outside of the range explored by the first test series, chances are that in one of the following test series it will certainly fall inside of the explored range. Furthermore, if the last test series has a spread of one, and the neutral point happens to fall within its range, we have the certainty that one of the test print colors will be the neutral one. However, an n^3 test series with a spread of 2 will in most cases give a sufficient degree approximation.

There may be need for a very minute final residual adjustment of the color balance of the printer if the desired printer light color happens to plot between the crosspoints of the color grid and not on any one of them. Since printer light combinations proceed by finite increments, it is theoretically quite improbable that, with any given adjustment of the standard combination, we will attain the desired color with absolute exactness; but, certainly, we will come to its closest possible vicinity. The printer light increments of additive color printers being as small as they are (approximately 6%), in most cases errors of the magnitude of one printer light or less can be considered as negligible since they do not appear as noticeable differences of color in the print or on the screen.

Some Economic Considerations

The economics involved in establishing color balance in additive color printing can only be considered briefly and in a general manner, since working conditions may differ markedly and accordingly influence the cost of the procedure.

It can be stated, however, that color balance can be established in two ways, that is by purely objective procedures or by a system of controlled chance. Both systems, when closely examined, have points of similarity. A purely objective procedure supposes previous knowledge of some parameters of the print material to be used with a certain type of negative stock. This may involve some prior testing of the print film and subsequent evaluation of the results before the first print can be made. This requires a trial print of some length. On the other hand, a system of controlled chance cannot be established with a reasonable degree of success without the use of some mathematics. Since both systems may lead us to the attainment of a correct print, the only factors to be considered are the time involved and the amount of film used.

Objective measurements, without doubt, will be the shortest route for obtaining the correct color balance when — and this is the deciding factor — only one type of color process is employed and when the relative color sensitivity of the print film is established and specified by the manufacturer. In this case a procedure can be worked out once and for all and some system of fixed, automatic or machine calculating can advantageously be used.

When several color processes are employed simultaneously — as may frequently be the case — and nothing is known in advance about the relative color sensitivity of the print stock, the time involved in establishing the print film parameters for each new coating by testing, mathematical evaluation and confirmation may be the same as, or may amount to more than, the time employed in establishing printer light color balance directly by a system of controlled chance. Here a system of controlled chance, once conveniently calculated and established, has the advantage that the same system may be applicable to any one type of color process, to any coating of print film, to any set of filters or, in short, to any set of printing conditions. Furthermore, such a system may be applied with success by anyone who has no command of mathematics, this taking quite a work load off the quality control department.

The only deciding factor which remains to be considered for a system of controlled chance is the amount of film utilized. This depends on the number of printer light combinations which comprise the test series, the number of repeat exposures of the test series, and the length printed with each individual printer light combination. These factors must be weighed against one another. A greater test series with a finer spread will give a higher probability for finding the neutral point at the first try; but, the initial cost will be higher. A test series with a few printer light combinations, but an ample spread, is almost certain to contain the neutral point within the explored range. Its initial cost will be low, but it may become necessary to make repeat exposures which represent additional time and extra costs for material. It has, however, the advantage that when the approximate location of the neutral point is known by previous testing for earlier prints on the same kind of stock, the spread of the series may be reduced, and consequently the probability for finding the neutral point may be increased. This may result in a substantial reduction in cost of film. On the other hand, the shorter the length of film used for printing each single test combination, the larger the number of different test combinations that may be made for a given quantity of film used. All these factors must be weighed according to the working conditions and equipment of each laboratory.

Summary

A practical system for a test series to establish and maintain printer light color balance in additive color printing by controlled chance is given. This system has been successfully in use for several years. It is believed that it provides an easy way to obtain matched color prints under variable printing conditions in additive color printing.

Acknowledgments

The author wishes to record his indebtedness to the late Antonio M. Bava, and to Juan Aranguren whose understanding and interest made this study possible; to Dr. Evaristo Fernández who helped in developing the system and in revising this paper; to Antonio Longo and his assistant Angel González under whose direction the print work for the investigation was made; to Juan Pugliese who directed the mechanical part of this program; and to Joaquín Pascual who made the illustrations.

References

1. G. T. Keene, A. J. Sant and J. D. Clifford, "A color timing calculating machine," *Jour. SMPTE, 67:* 763–767, Nov. 1958.
2. G. T. Keene, "A color timing and calculator for subtractive motion-picture printers," *Jour. SMPTE, 67:* 404–408, June 1958.
3. John G. Stott, William R. Weller and J. Edward Jackson, "Automatic timing of color negatives," *Jour. SMPTE, 65:* 216–221, Apr. 1956.
4. C. J. Bartleson and R. W. Huboi, "Exposure determination methods for color printing: the concept of optimum correction level," *Jour. SMPTE, 65:* 205–215, Apr. 1956.
5. J. W. Stafford and H. L. Baumbach, "A new color timer for motion-picture film," *Jour. SMPTE, 67:* 81–83, Feb. 1958.
6. Bernard D. Loughlin, Charles E. Page, William F. Bailey, Charles J. Hirsch, Arthur J. Miller and Leonard Giarraputo, "An instantaneous electronic color-film analyzer," *Jour. SMPTE, 67:* 17–26, Jan. 1958.
7. Jack E. Pinney and William R. Weller, "Calibration of color motion-picture printers," *Jour. SMPTE, 65:* 485–487, Sept. 1956.
8. Lloyd E. Varden, "A semiautomatic color analyzer," *Jour. SMPTE, 56:* 197–204, Feb. 1951.
9. C. A. Horton, "Printer control in color printing," *Jour. SMPTE, 58:* 239–244, Mar. 1952.
10. Richard L. White and Robert C. Lovick, "Glass filters for color printing," *Jour. SMPTE, 67:* 29–31, Jan. 1958.
11. Deane B. Judd, *Color in Business, Science, and Industry*, p. 280, John Wiley & Sons, New York, 1952.
12. Ralph M. Evans, W. T. Hanson, Jr. and W. Lyle Brewer, *Principles of Color Photography*, pp. 481, 486 and 503, John Wiley & Sons, New York, 1953.

Some Uses of Optical Masers in Photography

By J. S. COURTNEY-PRATT

The extraordinary brilliance of a focused maser beam makes it an ideal source for short exposure high-magnification micrography, and for shadowgraph and schlieren work. In addition, the monochromatism of the beam makes the maser light source exceptionally useful in interferometry. Pictures have been taken to demonstrate some of the capabilities of maser light sources.

LIGHT GIVEN OUT by an optical maser is nominally emitted as a nearly parallel, monochromatic, coherent beam, though in actual ruby masers these features of parallelism, monochromatism and coherence do not obtain precisely. The components of a typical ruby optical maser are shown diagrammatically in Fig. 1. The ruby absorbs light in a broad band of wavelengths from 5,000 to 6,000 A, and there are strong narrow fluorescent emission lines near 7,000 A.

If there is a small brief flash of light from the flashtube, the fluorescent emission rises and falls in the usual way, with a half life of about a millisecond. If, as was predicted by Schawlow and Townes,[1] and later demonstrated by Maiman[2,3,4] and others,[5,6,7] the intensity of the "pumping" light is sufficiently high that more than half of the Cr^{+++} ions in the ruby rod are raised to an excited level, then a wave of the appropriate wavelength traveling through the ruby will stimulate the emission of more quanta than are absorbed. The feature that is perhaps the most surprising is that the stimulated emission is in phase with the stimulating wave, and therefore that wave grows in intensity as it travels through the crystal

If the ends of the ruby rod are made flat and parallel, and are coated with a layer with a high reflection coefficient, the ruby behaves as a Fabry Perot etalon; and standing waves can be generated if the amplification per pass is greater than the losses on reflection at the ends. The reflecting layer is made partially transmitting at least at one end, and a proportion of the beam emerges from the ruby perpendicular to the end face.

A simple lens can be used to focus the beam to a very small spot. If the maser beam were precisely parallel and coherent, the spot of light could be as small as one wavelength in diameter. In the practical case the spot of light is larger than this, but one can fairly easily obtain a spot smaller than, say, 0.1 mm in diameter. The energy in a ruby maser beam is typically of the order of $\frac{1}{2}$ of a joule during the half millisecond of emission. This means that the illumination of the small spot image is very high indeed.

With the figures above, the mean power per unit area illuminating an object at the focus would be about 5.10^6 w/cm². This may be compared with the mean power per unit area in the image we could form with a lens concentrating light from the Sun. Even if we consider all the light in the whole visible spectrum, and use an $f/1$ lens, the mean power per unit area in the image of the Sun is only about 500 w/cm². The illumination provided by the focused maser beam is 10,000 times greater than this. Any of the usual continuously operable terrestrial light sources, and any images of such sources, no matter what condenser lens systems are used, are less bright than the image of the Sun.

If we wish to photograph a large object we need to illuminate it with a large total amount of light. If, on the other hand, we wish to photograph an object through a microscope, we need a high luminance, though the total luminous flux is not necessarily large because of the smallness of the field of view. An optical maser is, thus, of great prospective importance as a brilliant light source for short exposure pictures, particularly in micrography.

Experimental Work

To test this I tried out some simple experiments.[8] I set up a ruby optical maser, as shown in Fig. 2, and focused the beam of light using conventional microscope condenser optics. The spot of light at the condenser focus was 0.1 mm in diameter. Even with this rather simple setup it turned out to be bright enough for photography at very high magnifications. Figure 3 is an illustration of this. It is of some potassium titanate crystals taken at a magnification from object to emulsion of

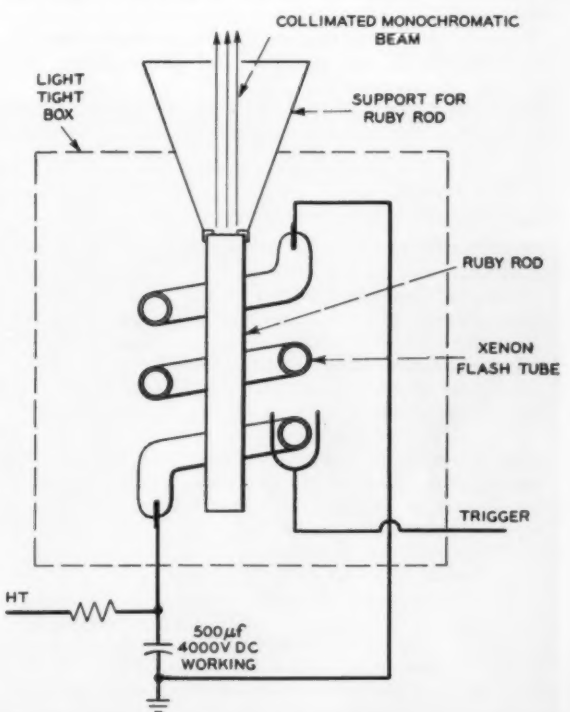


Fig. 1. Diagram of components of a typical ruby optical maser.

Presented on October 19, 1960, as part of a larger paper at the Fifth International Congress on High-Speed Photography in Washington, D. C., by J. S. Courtney-Pratt, Bell Telephone Laboratories, Murray Hill, N.J.

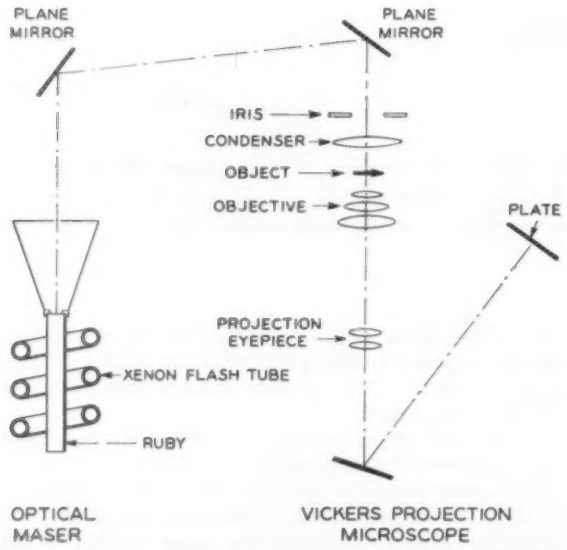


Fig. 2. The experimental arrangement for high magnification micrography by the light from an optical maser.

1800×, by the flash of light from a ruby maser. The needle-shaped crystals are 1 to 2 microns in diameter. The ruby rod was about 7 mm in diameter, 5 cm long, and was "pumped" by light from a General Electric type FT503 flashtube supplied from a condenser bank of 500 μf charged initially to 4,500 v. The burst of light from the maser lasted less than 1/2000 sec. The photographic plate was an Eastman Kodak Type I-L Spectroscopic Plate, with normal development. The condenser of the Vickers projection microscope was an aplanat of 12mm focal length and it gave an illuminated field 0.1 mm in diameter. The objective was a 4-mm N.A. 0.85 (metallurgical). The projection eyepiece was a 20× compensating.

It is also possible to use the light from a ruby maser in other aspects of micrography and photography. For example, the monochromatism of the beam may be of great use in interferometry. The Tolansky multiple beam interference techniques[9] are widely used to study surface topography. For such work one requires a collimated beam of monochromatic light. This is usually obtained from a low-pressure mercury discharge lamp followed by filters, condenser, aperture and collimating lens. The brightness is low and the exposures long. Most attempts to increase the lamp brightness also increase the working temperature, and so broaden the emission lines too much. The beam of light from an optical maser is ideal for multiple beam interferometric work. The beam is more precisely monochromatic than the usual light sources, and it is far brighter. Furthermore, it is sufficiently parallel that it may be used just as it emerges from the ruby — and the filters, condenser, apertures and collimating lenses may all be dispensed with. I recently took some pictures using the Tolansky sharpened Fizeau fringe technique. A diagram of the experimental arrangement is shown in Fig. 4.

Fig. 3. Potassium titanate crystals photographed at a magnification from object to emulsion of 1800× by the flash of light from a ruby maser.

Figure 5 shows the fringes formed between two pieces of smooth, fire polished glass, one of which is here being used as the reference surface, and the other as the specimen. The magnification from object to photographic plate was 10.5×. The array of fine fringes extending over the whole format was recorded with a single burst of light from the maser. It was operating at room temperature, and the mean wavelength then is 6943 A. After exposure to light from the maser, the lefthand side of the plate was covered by partial insertion of the darkslide. A collimated, filtered beam of light from a 125-w mercury lamp, working at pressure of a few atmospheres, was then directed to fall at normal incidence on the specimen and reference surface.

The exposure time for the 5461 A green mercury fringes was 10 sec. That is, the exposure time necessary with light from the maser was about 1/20,000 of the time that was necessary using an ordinary mercury lamp. Apart even from the obvious saving in time, when working at higher magnifications, this is a considerable advantage, as ordinarily it is difficult to avoid vibration which broadens the recorded image of the fringes; and it is difficult to avoid the creeping of fringes due to small slow changes in the relative positions of the specimen and reference flat caused by the heat absorbed from the illuminating beam. All of the energy in the maser beam is in the narrow monochromatic band at 6943 A. Thus, there is no unnecessary heating which otherwise would cause distortion of the specimen or reference flats and which would reduce the sharpness of the fringes.

The narrowness of the nominally monochromatic wavelength band emitted by the optical maser is evident in Fig. 5. The fringes are much narrower than those from the conventional mercury lamp and collimating system. This fringe sharpness allows much greater precision of measurement. The mercury line would seem to be about 2 A wide. It is estimated that the width, at half peak intensity, of radiation from a ruby maser working at room temperature is less than 0.5 A. Cooling the ruby to the temperature of liquid nitrogen changes the mean wavelength from 6943 to 6934 A, and the line becomes two or three times narrower.

Future Applications

The above examples by no means exhaust the possible uses of optical maser light sources in high-speed photography. There will be many interferometic applications, e.g. in shock tubes and wind tunnels. It also has been drawn to my attention that the maser may be a very valuable light source for high-speed photoelastic studies.[10] Recently it occured to me that one could make

use of a ruby maser along with a narrow pass filter for photographing objects when there is a high level of unwanted ambient light. The filters could cut down the extraneous light by a factor of a thousand or more, yet allow the maser light to pass almost without attenuation.

It is to be expected that, with further development, optical masers will be available which emit light more nearly monochromatic, parallel and coherent than do those used until now. It is also expected that the duration of the flash burst may be controlled at will, and that it may be more closely synchronized with any convenient trigger signal. All of these developments should make the optical maser an even more valuable light source for short exposure photography; and, in due course, for high-speed repetitive photography.

Summary

A ruby optical maser emits a nearly parallel, monochromatic, coherent beam. It is possible to focus the beam to a small spot, the luminance of which is higher than that of any other light source. In a typical practical case the power per unit area falling on a surface at the focus can be about 5.10^6 w/cm², i.e. 10,000 times more than the power per cm² in an image of the Sun, formed by an $f/1$ lens collecting light from the whole visible spectrum. The great luminance of such a spot makes it ideal as a light source for micrography. It would also be valuable in any other situation where a bright point source is wanted as, for example, in shadowgraph or schlieren work. The maser beam is monochromatic, with a line width less than 0.5 A. The light source is thus excellent for interferometry.

Pictures by the flash of light from a ruby maser have been taken through a microscope at 1800× with an exposure of 0.5 msec. Tolansky multiple beam interference techniques have been used to record sharpened Fizeau fringes at a magnification of 10×, with an exposure time 20,000 times shorter than was possible using a conventional mercury discharge lamp.

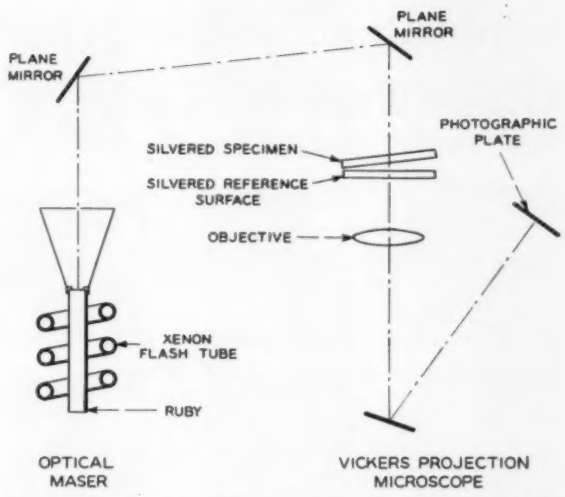


Fig. 4. The experimental arrangement for Tolansky multiple-beam interference micrography by light from an optical maser.

The maser light source is of great prospective importance in a wide range of short exposure photographic problems.

References

1. A. L. Schawlow and C. H. Townes, "Infrared and optical masers," *Phys. Rev., 29:* 1940–1949, Dec. 1958.
2. T. H. Maiman, *Nature, 187:* 493, London, 1960.
3. T. H. Maiman, *Phys. Rev. Letters, 4:* 564, 1960.
4. T. H. Maiman, *British Communications and Electronics, 7:* 674, 1960.
5. R. J. Collins, D. F. Nelson, A. L. Schawlow, W. L. Bond, C. G. B. Garrett and W. Kaiser, *Phys. Rev. Letters, 5:* 303, 1960.
6. A. L. Schawlow, "Solid state optical masers," presented at a meeting of the Opt. Soc. of Amer., March 2, 1961.
7. R. J. Collins and D F. Nelson, "Studies of the emission from a pulsed ruby optical maser," presented at a meeting of the Opt. Soc. of Amer., March 2, 1961.
8. J. S. Courtney-Pratt, "Optical masers and micrography," *Bell Laboratories Record, 39:* 142–143, 1961.
9. S. Tolansky, *Multiple Beam Interferometry*, Clarendon Press, Oxford, 1948.
10. Horst P. Richter, private communication.

Fig. 5. Sharpened Fizeau fringes. The array of fine fringes extending over the whole format was taken by light from an optical maser. The second exposure was restricted to the righthand side of the plate. These broader fringes are from a conventional mercury lamp. The exposure time with the mercury lamp was 20,000 times longer than with the optical maser.

Applications of the Type C5 Rotating Mirror Framing Camera

By K. R. COLEMAN and A. SKINNER

At the Fourth International Congress on High-Speed Photography five separate papers were presented describing various aspects of the high-speed photographic work carried out at the British Atomic Weapons Research Establishment. The present paper describes three applications of the Type C5 camera at speeds up to 8 × 10⁶ frames/sec on such events as θ-mode discharges and externally illuminated effects of explosions.

In the papers given by AWRE personnel to the Fourth Congress[1-5] several cameras were described, but there was time to show only a few pictures. This was particularly true of the Type C5, at that time in the prototype stage. This paper describes three applications of that camera.

The C5 was designed as an approach to a universal camera; many framing rates were to be available with the mirror always running at optimum speed. It is apparent, therefore, that the characteristics of the optical systems suit each experiment and they will be given below. The speed chosen as optimum, however, can be given here as it does not vary from experiment to experiment. For long life and trouble-free running 6000 rps is not exceeded for a 27-mm mirror; the top speed available is 7000 rps. So far the highest frame rate used has been 8×10^6 frames/sec although it is possible to go to 10^7 (see Fig. 1).

Presented on October 21, 1960, at the Fifth International Congress on High-Speed Photography in Washington, D.C., as a part of paper No. 85, "Progress in High-Speed Recording at Atomic Weapons Research Establishment" by K. R. Coleman (who read the paper) and A. Skinner, Atomic Weapons Research Establishment, Aldermaston, Berks, England.

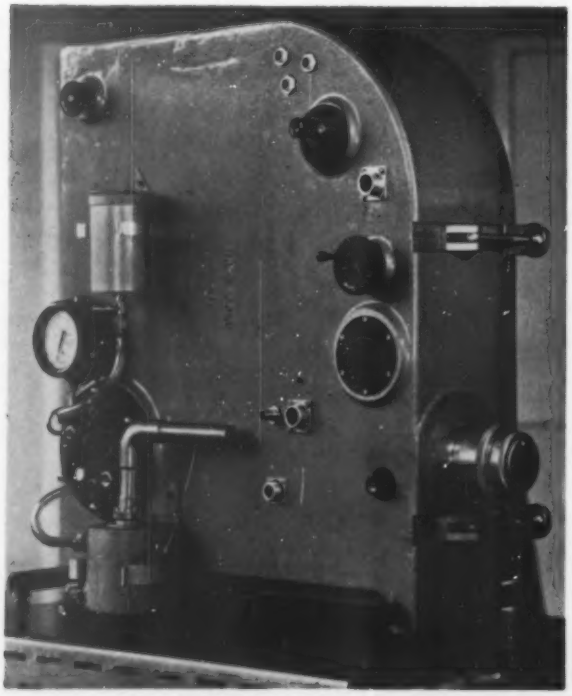


Fig. 1. The AWRE C5 Camera.

The first example shows that non-self-luminous objects can be photographed at these rates. The problem was to investigate the strain due to shock in a metal plate. The plate was painted white with a black grid marked on it, and a 25-mm cube of high-explosive was detonated behind and in contact with it. The illumination was by two argon flash bombs situated directly in front of the plate, pointing slightly downwards, and at a distance of 150 mm. The camera was at 45° to the plate, set to run at 7.5×10^6 frames/sec, 75-mm overall focal length, and

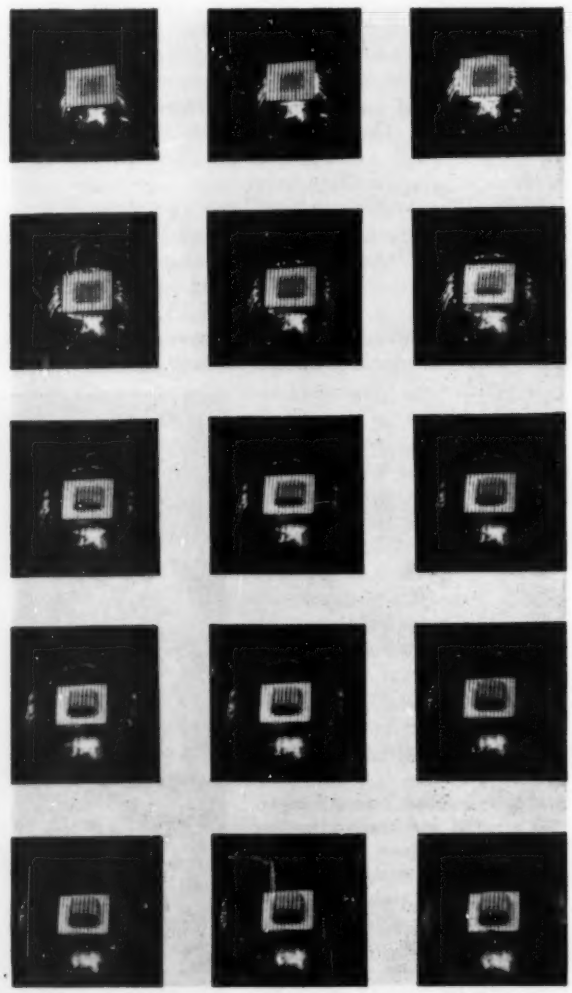


Fig. 2. Strain in a metal plate — a sequence taken with the C5 Camera.

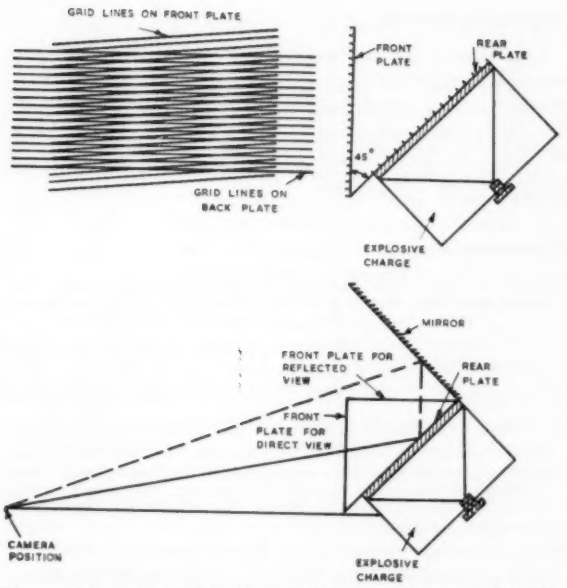


Fig. 3. Above, formation of moiré fringes by crossed grids; below, diagram of charge arrangement. Camera position is not shown to scale; it is further from the charge than is shown, so that the line of sight of direct and reflected views are almost parallel.

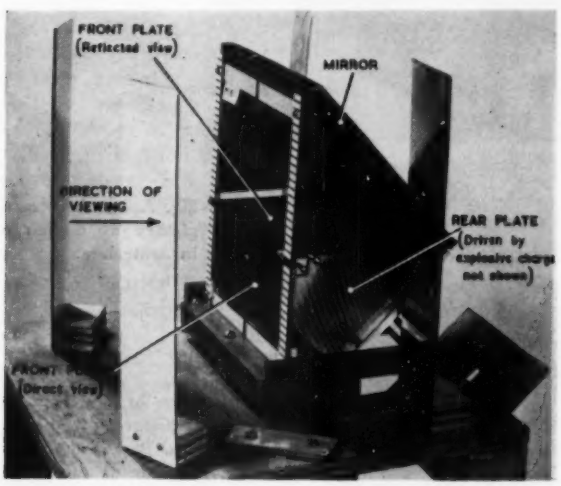


Fig. 4. Experimental arrangement for C5 moiré fringe technique.

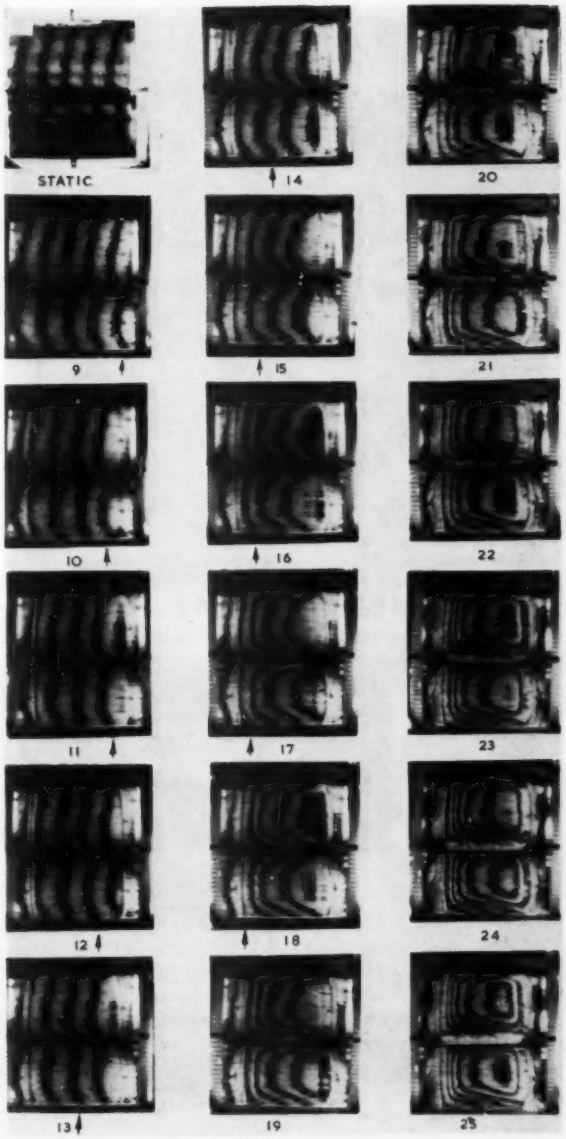


Fig. 5. Sequence of C5 moiré fringe pictures: frame numbers identify each picture; frame interval, 0.69 μsec; nominal exposure, 0.10–0.15 μsec; arrow indicates motion of a particular fringe from right to left.

$f/14$ at the film. The picture size is 8 mm. The work is part of a program carried out by Cachia and Clark[6] (see Fig. 2).

The second example is again an explosive technique; but this shows the possibility of really accurate measurement of displacement or velocity by moiré fringe methods. In this experiment the frame interval was about 0.7 μsec, the focal length of the camera 460 mm, and the fringe velocities about 10 mm/μsec. The exposure time of each frame was 0.10 μsec nominal, and the illumination was again by argon flash bombs. The picture size is 20 mm. The work is part of a program carried out by Fawcett and Schofield[7] (Figs. 3–6).

The third example is concerned with a study of the compression of a deuterium plasma by an axial magnetic field generated by a wide single-turn coil. This has been carried out by Green and Niblett[8] using the C5 camera and the S4 streak camera.

Discharges in deuterium at initial pressure varying from 50 to 100 microns were photographed axially, the streak camera recording at 20 mm/μsec, the framing camera at 8×10^6 frames/sec. Pictures 8 mm in diameter at $f/14$ were obtained, the overall focal length being 190 mm (Figs. 7 and 8).

The photographs show successive stages of one discharge. The cylindrical implosion shows up clearly and so do the flutings typical of Rayleigh-Taylor instabilities. Furthermore, it can be seen that the plasma is not rotating although the blurring of focus shows that it is being ejected from the center section of the tube.

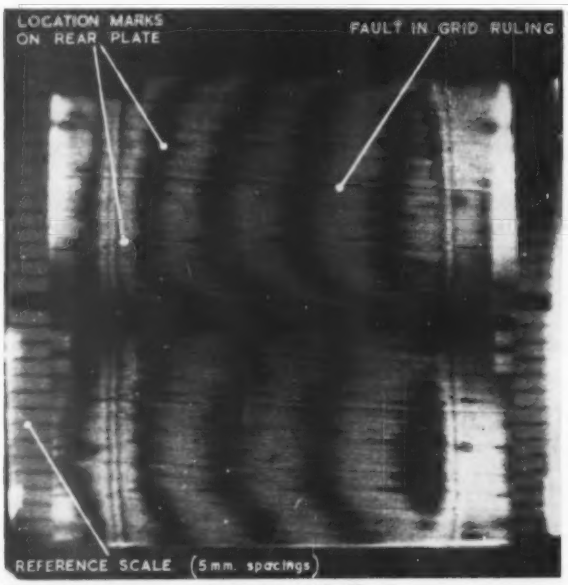


Fig. 6. Enlargement of frame No. 14 in Fig. 5.

Acknowledgments

Our thanks are due members of our section who have worked so hard on high-speed camera projects, in particular to R. J. Abrey and A. E. Huston who have been especially concerned with the work described here. We are also grateful for the help and encouragement given to us by I. Maddock.

References

1. K. R. Coleman, "The photography of high temperature events," *Proc. Fourth International Congress on High-Speed Photography*, Verlag Dr. Othmer Helwich, Hoffmannstr. 59, Darmstadt, Germany, 1959, pp. 32–39.
2. K. R. Coleman, "Some problems in the design of lenses for high-speed photography," *ibid.*, pp. 81–84.
3. A E. Huston, "Some developments in rotating mirror cameras," *ibid.*, pp. 163–166.
4. A. Skinner, "A versatile rotating mirror camera," *ibid.*, pp. 172–176.
5. G. H. Lunn and E. D. Menzies, "A comparison of Kerr cells and image tubes as high-speed shutters," presented at the Fourth International Congress on High-Speed Photography, Cologne, 1958; to be published in the *Proceedings* of the Fifth International Congress on High-Speed Photography as paper C–8.
6. G. P. Cachia and D. Clark, AWRE, (private communication).
7. L. G. Fawcett and A. Schofield, AWRE (private communication).
8. T. S. Green and G. B. F. Niblett, AWRE, *Nuclear Fusion*, 1: 42, 1960.

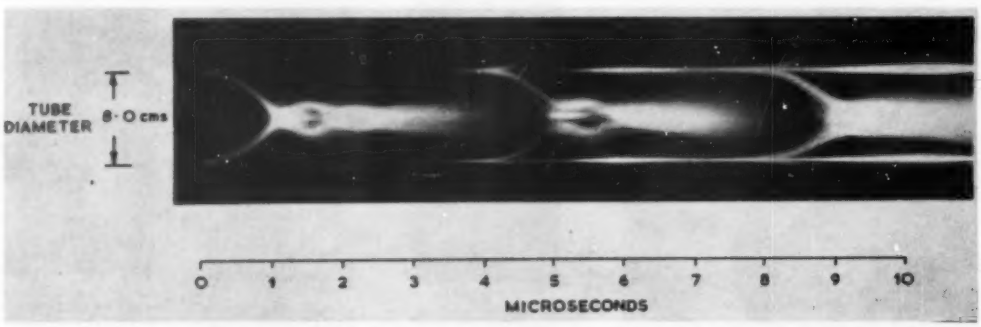


Fig. 7. Streak camera picture of discharge in deuterium.

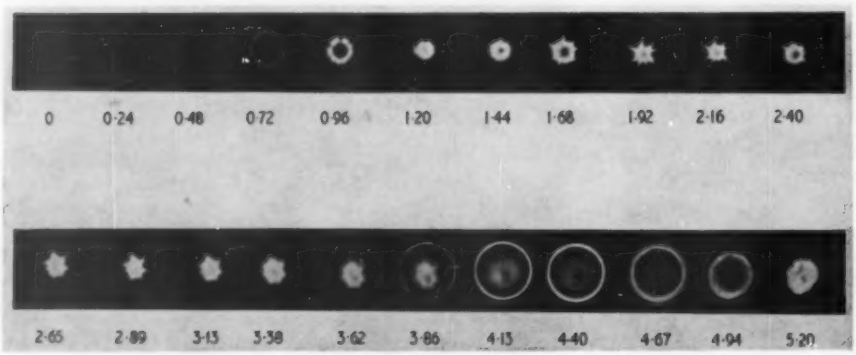


Fig. 8. Discharge in deuterium — a sequence of pictures taken with the C5 Camera. Photographs of a thetatron discharge at an initial pressure of 150 microns using a high-speed framing camera which viewed the discharge axially. The time in μsec from the beginning of the first implosion is shown under each photograph. The exposure time of each frame is 0.12 μsec.

Ed. Note: The Fifth International Congress on High-Speed Photography was sponsored by the SMPTE and supported in part by the Departments of Army, Navy and Air Force through a grant administered by the Chief Signal Officer of the Army. Congress papers and related discussion will be published in the *Proceedings* of the Congress.

What Is the Sensitivity of a Photographic System?

By FRED H. PERRIN

The concept of informational sensitivity is derived intuitively as the gradient $g = dD/dE$ divided by the product of Selwyn granularity $\mathfrak{g}$ and the square root of the area s of the spread function. When the diameter of the camera lens and the size of the final picture are held constant, the relative focal length of the camera lens for equal detail rendition varies directly with the product $\mathfrak{g}\sqrt{s}$. The required exposure time then varies inversely with informational sensitivity $g/\mathfrak{g}\sqrt{s}$. For a stationary camera, detail rendition improves as the focal length of the camera lens increases. But the exposure time also increases, and when the camera moves relatively to the scene, detail rendition is thus diminished from this cause and is optimum for a certain focal length. Examples are given to confirm these conclusions.

ALL OF YOU from English-speaking countries and many from other countries know the fantastic tales written by an English mathematician under the *nom de plume* of Lewis Carroll for his 12-year-old friend Alice. After stepping through a looking glass and experiencing many strange adventures, according to Carroll's story, Alice comes upon the Mother Goose character, Humpty Dumpty. She immediately gets off on the wrong foot by mistaking his necktie for a belt, and this leads to a discussion of semantics which he ends peremptorily by the declaration: "When *I* use a word, it means exactly what I choose it to mean — neither more nor less." Analogously, I am going to use the term "sensitivity" today in an exact way but in a way that may be rather different from what we are accustomed to.

Suppose that two automobiles are to be compared for gasoline consumption. It may be that automobile A will use less gas over a 10-mile course when both cars are driven at 60 miles an hour but that automobile B will use less gas if each car is driven at its own most efficient speed. It is rather easy to determine the most efficient speed of an automobile by trial, but to determine the most efficient conditions for using photographic films so that the sensitivities of films can be compared fairly is more difficult. The procedure that I shall describe here has been described in greater detail elsewhere by my colleagues, and I shall confine myself to emphasizing the principles.

The photographic effect produced by a certain exposure is a blackening of the emulsion that is evaluated quantitatively by the optical density. The relation of the effect — density — to the cause — exposure — is ordinarily represented by what are known as characteristic curves relating density to log exposure. Figure 1 shows such curves for emulsions ranging from a very high speed landscape film to a document-recording film.* Although the trade names of most of these films can be deduced by comparison with the references, the films are identified in this paper only by letters to avoid distracting attention from the principles that they are intended to illustrate. The exposures were made in a monochromatic sensitometer to light of wavelength about 420 mμ. It is true that blue light would rarely be used to expose these films, but for many of them data were already available for light of this spectral quality and no other when this paper was outlined.

This type of graph, although convenient for most purposes, does not relate cause and effect directly because the exposure scale is logarithmic. The direct relation is given by a graph like Fig. 2, where exposure is plotted on a natural scale. This figure indicates the exposure time required for a lens of a given relative aperture. On the face of it, the slow emulsions E and F are hopelessly out of the running.

But in high-speed photography, as in most technical applications of photography, the purpose of the photographic process is to transmit information. In information theory, the effectiveness of a system is determined by the signal-to-noise ratio. Now the *signal* in a photographic system is represented by density. At a certain exposure E (Fig. 2), a small incremental exposure ΔE produces a small incremental density ΔD. This incremental density has to be great enough to be observed, but the exact amount is not important for the present argument.

Presented on October 21, 1960, in an abbreviated form at the Fifth International Congress of High Speed Photography in Washington, D.C., by Fred H. Perrin, Research Laboratories, Eastman Kodak Company, Rochester 4, N.Y.

*The data presented here are purely for illustration and many are in no way representative of the films as now marketed or as processed in practice. The characteristics of some of the films have been changed, the data have been obtained at various times and under conditions that are not strictly comparable, and some of the films were processed under conditions that are widely different from those followed in practice.

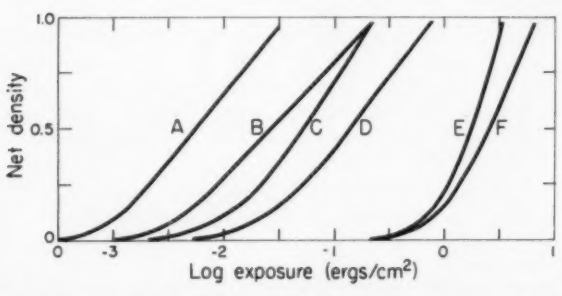


Fig. 1. Characteristic curves of six negative films selected for illustration. They range from (A) high-speed landscape film to (F) microfilm.

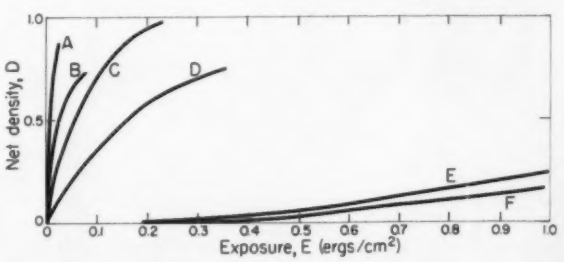


Fig. 2. Characteristic curves of films on a natural scale of exposure. Replotted from Fig. 1.

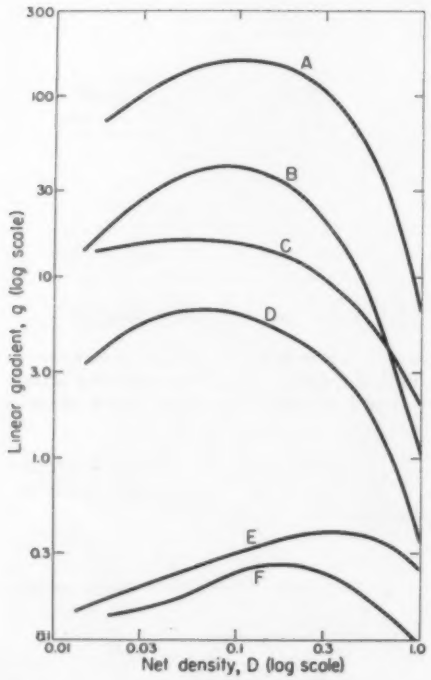


Fig. 3. Informational gradients of the six selected films as a function of density. The density scale is logarithmic and extends between 0.01 and 1.0.

Fig. 4. Microdensitometer trace representing granularity superposed on track of scanning aperture.

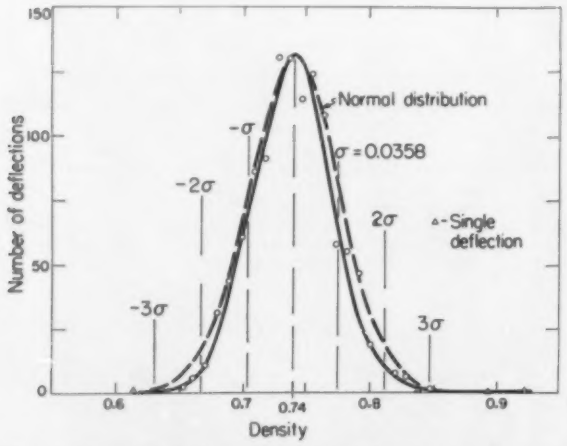


Fig. 5. Size distribution of microdensitometer deflections. The distribution representing the granularity of a certain film for a certain scanning aperture is shown by the solid curve and the normal or Gaussian distribution is shown by the broken curve. The deflections have been converted into their corresponding density values along the axis of abscissas. The extreme values given by single deflections may arise from dirt and pinholes.

The important thing is the ratio $\Delta D/\Delta E$, which at the limit becomes the derivative

$$g = dD/dE. \tag{1}$$

This quantity will be called *linear gradient* to distinguish it from the more common *sensitometric* or *logarithmic gradient*

$$G = dD/d \log E. \tag{2}$$

It is plotted† for the six selected films in Fig. 3. The low values of density at which the maxima are exhibited are noteworthy. The range of the maxima between the extreme films A and F is of the order of 1 : 1000.

In a photographic system, *noise* is to be interpreted as the granularity of the emulsion. Granularity can be evaluated by scanning a uniformly exposed and developed sample of the emulsion with a microdensitometer. The procedure is indicated by Fig. 4, where the microdensitometer deflections are superposed on the track of the scanning aperture. If the size of each of a large number of such deflections (a thousand or more) is determined and the number having sizes that fall within narrow limits is plotted against the size itself, a curve like the solid curve in Fig. 5 is obtained. Each point shows, for an actual emulsion, the number of deflections representing the density indicated ± 0.0045. (More briefly, each point represents a size class of 0.009.) This curve can be specified by the standard deviation σ, which in this case is 0.0358. The normal or Gaussian distribution curve for this same standard deviation is shown by the broken line. The correspondence is close, and an equally close correspondence has been found for the other samples that were evaluated. The parameter σ‡ may thus be taken as a measure of granularity. For the normal curve (broken in Fig. 5), it is the abscissa distance from the mean in either direction to the point of inflection.

But we not only want as high a signal-to-noise ratio as possible; we also want to make the camera exposure in the shortest possible time. This means that the image on the fiim in the camera must be as small as possible so that the light flux will be highly concentrated and the film illuminance high. Reducing the size of the negative also reduces the length of the camera, often a desideratum. Nevertheless, there is a limit to this shrinking procedure.

Any scene can be considered to be made up of an assemblage of infinitesimally small points. The image of a point is therefore the building block out of which the image of an extended object is constructed. Even if the lens could form a perfectly dimensionless image of a point, the photographic image would have finite dimensions because of the diffusion of light within the emulsion, and this image is by definition the spread function of the emulsion. Figure 6 shows the spread functions for light of wavelength 420 mμ of the films whose characteristic curves are given in Fig. 1.

It is obvious that the more spread functions, or building blocks, that can be crowded distinguishably within the boundaries of the negative, the more information the

†Logarithmic scales are used for this and later graphs, partly to cover the wide range of values and partly to expand the region of low densities. The values of net density are measured from the respective fog values.

‡This is often written $\sigma(D)$ to indicate that it is expressed in terms of density D and not transmittance T.

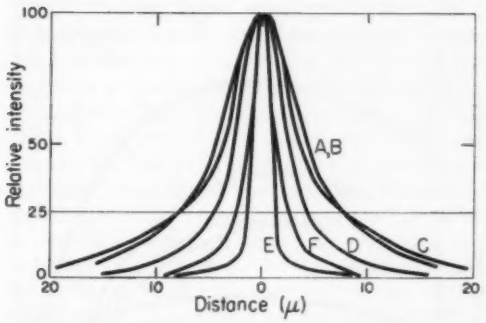


Fig. 6. Point spread-functions of the selected films.

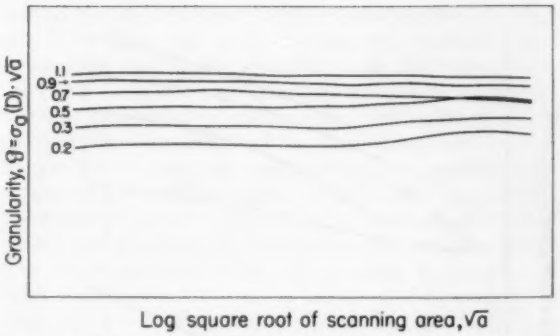


Fig. 7. Selwyn granularity as a function of the square root of the area of the scanning beam. The curves are for a certain uniformly exposed and developed emulsion at the densities shown.

negative will convey. If the area of this spread function is s,§ then what we may call the *informational sensitivity* of the system is proportional to $1/s$, other things being equal, because this ratio represents the maximum number of elements of information that can be transmitted by the system.

The size of the spread function s also has another implication. You are undoubtedly aware that the microdensitometer deviations representing granularity increase in size as the scanning aperture is reduced in size. It was shown[1] over twenty years ago that the product of σ and the aperture diameter or square root of the aperture area should be constant as the aperture size is changed. For many years experiments[2] did not bear out this conclusion; the product was usually slightly high at low densities and markedly high at high densities. Within very recent years, much more sensitive microdensitometers have become available and it has been found[3] that the product is indeed a constant if extreme care is taken to make the samples perfectly clean and also free from a gradual change in density from one side to the other. This is shown by Fig. 7, which shows the product of σ and the square root of the area of the scanning spot plotted against the latter for a certain emulsion exposed to give a series of densities. We may therefore take the quantity

$$\mathfrak{G} = \sigma_a(D)\cdot\sqrt{a} \tag{3}$$

as a measure of granularity, where a is the area of the scanning aperture. This constant varies somewhat with development conditions, and, as Fig. 8 shows, it is definitely a function of density, although it is not subject to extremely wide variations over moderate density ranges.

In studying informational sensitivity, we are interested in an area the size of the spread function s because that is the smallest significant area of the emulsion. We may therefore write granularity as

$$\mathfrak{G} = \sigma_s\cdot\sqrt{s} \tag{4}$$

since $\mathfrak{G}$ is invariant with s.

We have seen intuitively that it is reasonable to say that informational sensitivity is directly proportional to the gradient $g = dD/dE$ and inversely proportional to the product of the standard deviation in granularity σ_s and the area of the emulsion spread-function s. Expressed mathematically, it means that informational sensitivity is given by the fundamental formula

$$I = g/\sigma_s\cdot s. \tag{5}$$

This equation has been derived elsewhere with greater rigor.[4]

The denominator of this equation can be rewritten

$$\delta_s\cdot s = \delta_s\sqrt{s}\cdot\sqrt{s} = \mathfrak{G}\sqrt{s}. \tag{6}$$

This quantity is plotted in Fig. 9. (The term used to designate the ordinates will be explained later.) Although the range in $\mathfrak{G}$ is only about 1 : 10 (Fig. 8), it increases to 1 : 40 for $\mathfrak{G}\sqrt{s}$ because, in general, the grainier films have the larger spread functions.

Informational sensitivity can now be written

$$I = g/\mathfrak{G}\sqrt{s}. \tag{7}$$

The values for the six films below unit density are plotted in Fig. 10. The range is rather great at low densities but is surprisingly small near unit density; at most, it is much less than the range of 1 : 1000 for g shown in Fig. 3.

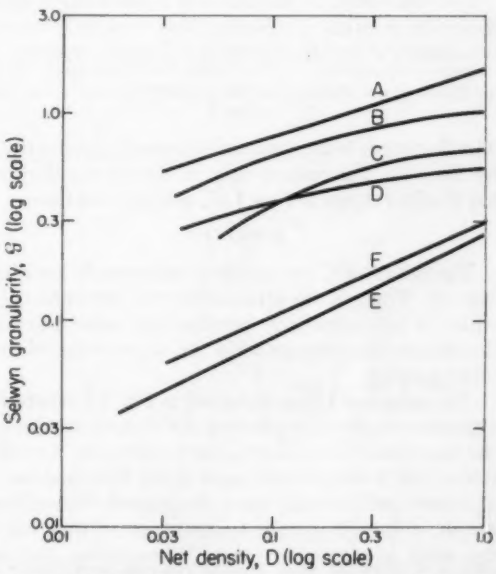


Fig. 8. Selwyn granularity of the six selected films as a function of density. The diameter of the scanning aperture was 24 μ.

§ The contour whose area is to be taken to represent the size of a function with sloping sides is, of course, largely arbitrary; the area for the 25% contour has been taken here for computing the graphs shown later. Another suggestion is to take $\pi\sigma^2/4$, where σ is the standard deviation of the function. A third way, described in the appendix to Reference 4, is to take the area of a flat-topped spread function producing the same band-pass in the frequency domain as does the spread function in question.

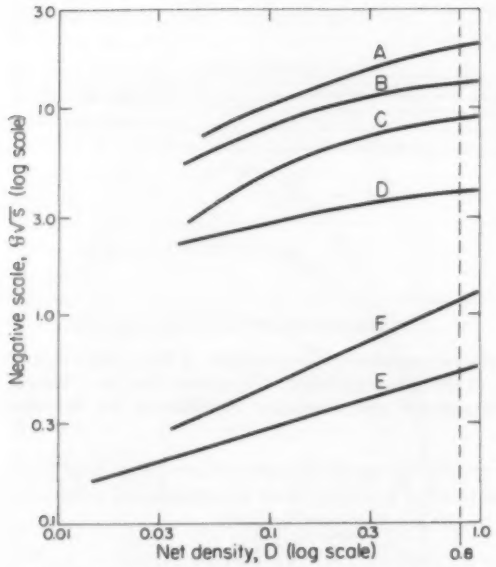


Fig. 9. Negative scale required for equal detail rendition on the six selected films as a function of density. Negative scale also indicates the focal length of the camera lens or the length of the camera.

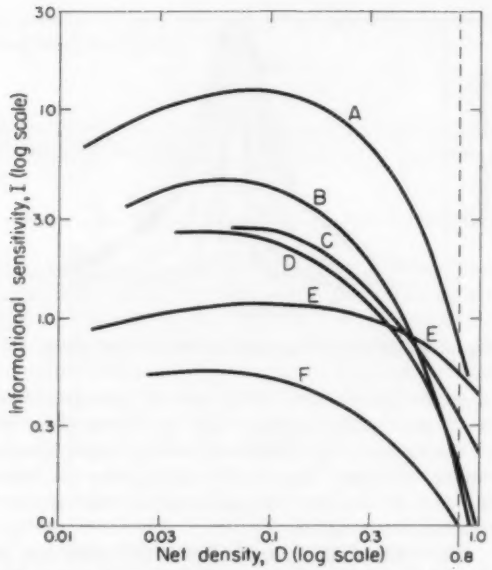


Fig. 10. Informational sensitivity of the six selected films as a function of density. This indicates the relative exposure time required for the negative scales indicated by Fig. 9.

A dimensional analysis shows that Eq. (5) indeed represents sensitivity. Such an analysis of the equation gives

$$[g/\sigma_s s] = \frac{[D]}{[P][L]^{-2}[T]} \cdot \frac{1}{[D][L]^2} = \frac{1}{[P][T]}, \tag{8}$$

where D is density and P is radiant power (sometimes weighted so that it can be expressed in units that indicate its visual or photographic effect), which it is not necessary to analyze further. This equation indicates clearly that sensitivity represents the inverse of the product of radiant power and the time for which it acts — the terms in which sensitivity must logically be expressed.

It is interesting at this point to make a slight digression to see the relation of informational sensitivity to ordinary sensitometric speeds. Equation (1) can be written

$$g = \frac{dD}{d \log E} \cdot \frac{d \log E}{dE}. \tag{9}$$

The first term is the usual sensitometric gradient, defined by Eq. (2). The second term is simply the derivative of $\log E$ with respect to E or $1/E$, and thus we have

$$g = G \cdot (1/E). \tag{10}$$

The values of G for the films under study are plotted in Fig. 11. There is no great difference between the films, which is not surprising because they were intentionally developed to approximately the same value of development gamma.

The values of $1/E$ are plotted in Fig. 12, where E is the exposure required to produce the density represented by the abscissas. This quantity obviously bears a crude relation to the sensitometric speed of the film, and for lack of a better term, it has been designated "speed" on the graph, although it must be emphasized that this use of the term is extremely loose. Nevertheless, the relation between sensitometeric speed and $1/E$ is close enough to warrant the conclusion that sensitometric speed is an extremely important factor in informational sensitivity.

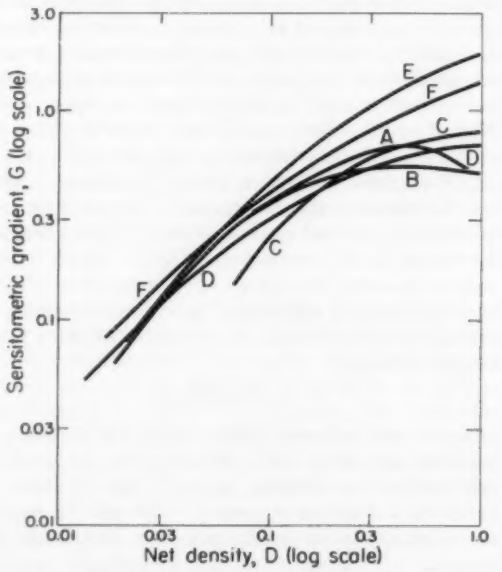


Fig. 11. Sensitometric gradient of the six selected films as a function of density. The development conditions had been chosen so that the gradients would not be widely different.

An interesting relation can be derived by substituting Eq. (10) in Eq. (7) to give

$$I = G(1/E)/\mathcal{G}\sqrt{s}. \tag{11}$$

The size s of the spread function is not greatly different for films of a single type (*cf.* films A, B, and C in Fig. 6), and when films are compared, the sensitometric gradient G is usually maintained constant. Setting G and s constant makes this equation roughly equivalent to the speed/grain ratio that is often used as an index of quality for films. Although this index is a convenient rule-of-thumb guide, its limitations are shown by the present derivation.

Now we can apply these principles to a particular photographic system. The system[5] whose sensitivity I am going to discuss is shown in Fig. 13, where a camera lens L_1 forms an image A_1 in the camera and this image is magnified by the enlarger M_1 to form a final image A'. (This is an unorthodox system in the sense that the camera and the enlarger are in the same box, but I am constructing my hypothetical system this way to emphasize that the important thing is to produce a final image A' that shall have the same size, regardless of how it is obtained. The image A_1 on the negative E_1 is merely a means to this end; it can be made of any suitable size by varying the focal length of the camera lens, and the magnification in the enlarger can then be selected to compensate. We shall assume that the enlarger does not degrade the image and thus cause information to be lost in the enlarging process.)

The first decision to be made concerns the size of the negative or, more precisely, the scale of the negative. A little consideration will show that it must be related to the denominator of Eq. (5), which is given by Eq. (6) and which is purely geometrical. A psychophysical study[6] of a very extensive series of photographs has shown that this quantity (more precisely, the equivalent for that particular study) is proportional to detail rendition as judged visually when the proper exposure is used for each negative. Thus we may say that the quantity $g\sqrt{s}$ determines the relative negative scale for equal detail rendition. This is the reason for considering the ordinates of Fig. 9 to represent negative scale. This graph therefore indicates the focal length of the camera lens and thus the length of the camera in an orthodox system consisting of a separate camera and enlarger. Then I in Eq. (7) indicates the exposure required to give the predetermined density. As an example, if the spread function of emulsion X has four times the area of that of emulsion Y, negative X must have twice the scale of negative Y to record the same detail and thus camera X must be twice as long as camera Y. If, then, the informational sensitivity of emulsion X is four times that of emulsion Y, the exposure time will be the same (always assuming that the lens diameters of both cameras are the same). Both cameras will then record the same detail in the same exposure time although one camera must be twice as long as the other.

Up to this point any modification of the image that might be formed by the lens has been disregarded. The spread function of a perfect lens can be computed, and it is plotted in Fig. 14. The scale of abscissas in units of length in the image plane varies directly with the focal length of the lens and inversely with its linear aperture. With the lens aperture constant, as is assumed here, the scale of this spread function is clearly proportional to the scale of the negative and hence it is a constant as the focal length of the camera is changed. If it is small enough it can be neglected, especially since it is a constant factor. As the focal length becomes short, the relative aperture increases and hence aberrations may become perceptible.

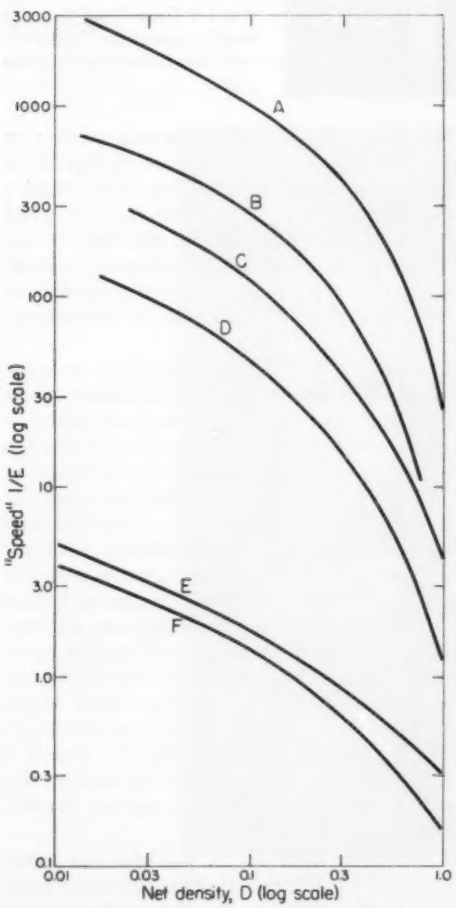


Fig. 12. The "speed" $1/E$ of the six selected films as a function of density. Here the term "speed" is used only in lieu of a better term; it bears only a very rough relation to true sensitometric speed. The quantity E is defined by Eq. (10).

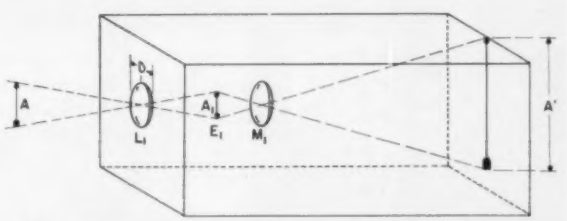


Fig. 13. An imaginary realization of the photographic system discussed here. The significance of the symbols is explained in the text.

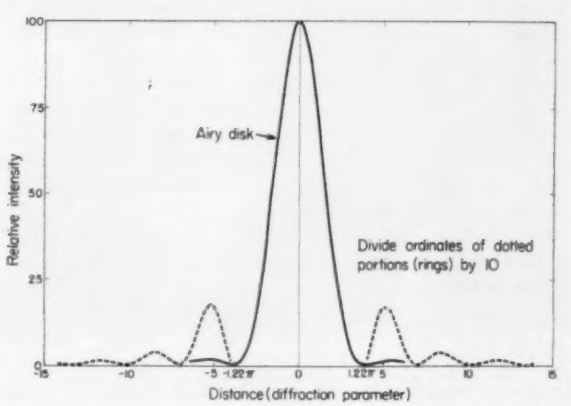


Fig. 14. Theoretical spread-function (airy pattern) of a diffraction-limited lens. The diffraction parameter is $\lambda f/\pi D$, where λ is the wavelength of the light and f and D are the focal length and the diameter of the lens, respectively.

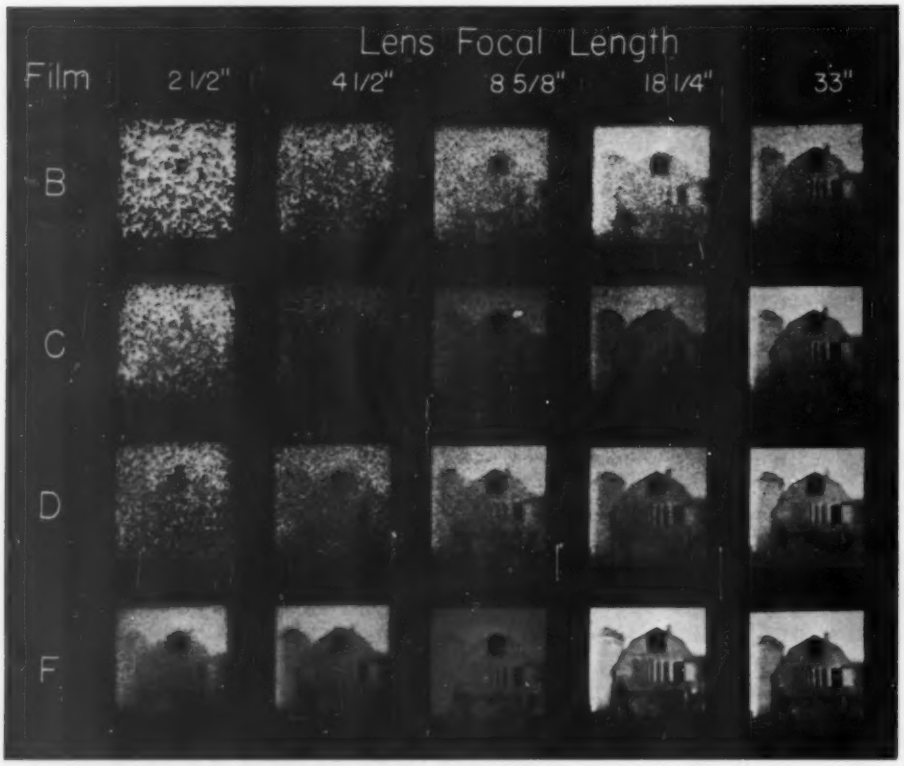


Fig. 15. Display of photographs made by the indicated lenses on the indicated films. Note that the detail rendition improves both downwards and to the right.

In any practical situation, this circumstance must be considered, but it will be neglected in this less detailed treatment.

The magnitude of $\varsigma \cdot \sqrt{s}$, on the other hand, depends only on the film and is independent of the scale of the negative, which means that its effect on detail rendition varies inversely with the scale and hence inversely with the focal length of the camera lens. This means that detail rendition should continually improve with increasing focal length of the camera lens.

A partial confirmation[5] of these conclusions is provided by the set of pictures in Fig. 15. The pictures in each column were all made with a lens of the focal length indicated, and thus the negative scale increased for each column from left to right. The films are arranged in the order of the negative scale required according to Fig. 9. Detail rendition obviously improves towards the right and downwards. A closer examination shows that the picture in the upper right-hand corner, made on film B with the 33-in. lens, is approximately as good as the one made on film C with the $18\frac{1}{4}$-in. lens, film D with the $8\frac{5}{8}$-in. lens, or film F with the $4\frac{1}{2}$-in. lens. It was found that the exposure time required for these pictures was approximately the same in the case of films B, C, and D.

These practical results can be compared with the theoretical expectations with the aid of Fig. 16, where the films are evaluated relative to film E at a density of 0.8. For each film, the open bar represents negative scale, interpreted here as relative camera length (broken vertical line in Fig. 9), and the hatched bar, the relative exposure required for this negative scale (broken vertical line in Fig. 10). The relative exposures required for films B, C, and D appear to be rather different instead of alike, as was found experimentally, but reference to Fig. 10 shows that the relative values depend greatly on density and would be changed with respect to one another by reducing the density somewhat. The scene in Fig. 15, of course, embraced a range of densities. The relative camera length is only slightly dependent on density, and there is an approximately quantitative agreement in this respect between Figs. 16 and 15. This agreement extends to film F, and this film is so slow that a very prolonged exposure was required for the pictures, in accordance with Fig. 16.

When the camera is moving with respect to the scene being photographed,[6] the variation in illuminance on the image plane arising from the motion has been found to follow approximately the normal distribution law shown by the broken curve in Fig. 5. Since the standard deviation σ increases with exposure time (the lens aperture and the type of shutter being assumed to be constant) and the exposure time required varies inversely with the illuminance of the image, which, in turn, varies inversely with the square of the focal length of the camera lens, it follows that the exposure time required increases with the focal length of the lens. Since the values of σ of the other elements are either constant or diminish with increasing focal length, it is evident that a certain focal length results in optimum detail rendition when the camera is moving. This is clearly shown by Fig. 17, which is exactly analogous to Fig. 15, except that the camera was moved relatively to the scene at the angular velocity shown in the righthand column.

Although the linear diameter of the lens was maintained constant during the experiments described here, the results can be transferred to any other set of conditions, such as constant relative aperture. As pointed out previously, the spread function of the lens must be taken into consideration if it is not negligible compared with the spread function of the emulsion.

Conclusions

Informational sensitivity thus appears to furnish a sound basis for comparing photographic systems. As an example of its application, let us consider the extreme films, A, E and F whose characteristics are given in this paper. Figure 16 shows that, compared with film E, the grainy, high-speed film A requires only half the exposure but a camera length six times as great. This length might be prohibitive for reasons of space, and when the camera is moving, the resulting blur might far overbalance the comparatively slight reduction in blur caused by the shorter exposure time. On the other hand, although film F would require a camera only 50% longer than would film E, it would require over five times the exposure. Indeed, it was necessary to use a speed that was 5% of the speed used for the other films to make the pictures displayed in Fig. 17 with an exposure time within the range of the shutter. Film E was introduced for limited practical use in aerial photography only within the year, and practical tests have borne out the estimate of its performance indicated by this analysis.

And so, as Humpty Dumpty might say, when the term "sensitivity" is to be used in connection with the type of problem discussed here, it should be chosen to have the meaning that it has been given here.

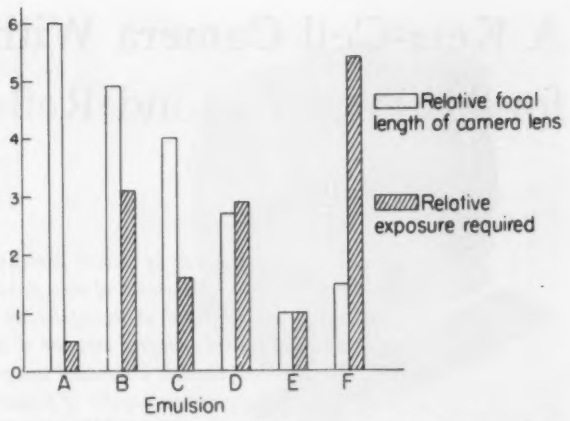


Fig. 16. Relative focal length of camera lens (camera length or negative scale) for equal detail rendition, and relative exposure required for that negative scale for the six selected films. The values for film E are taken as unity.

References

1. E. W. H. Selwyn, "A theory of graininess," *Phot. J., 75:* 571–580 (1935); *82:* 208 (1942).
2. E. W. H. Selwyn, "Experiments on the nature of graininess," *Phot. J., 79:* 513–524 (1939); L. A. Jones and G. C. Higgins, "Photographic granularity and graininess. II. The effects of variations in instrumental and analytical techniques," *J. Opt. Soc. Am., 36:* 203–227 (1946).
3. G. C. Higgins and K. F. Stultz, "Experimental study of rms granularity as a function of scanning-spot size," *J. Opt. Soc. Am., 49:* 925–929 (1959).
4. H. J. Zweig, G. C. Higgins, and D. L. MacAdam, "On the information-detecting capacity of photographic emulsions," *J. Opt. Soc. Am., 48:* 426–933 (1958).
5. R. N. Wolfe, "Detail rendition by photographic systems as a function of exposure time," *J. Opt. Soc. Am., 49:* 172–175 (1959).
6. R. N. Wolfe and S. A. Tuccio, "The Effect of the variables of a photographic system on detail rendition, with special reference to camera motion," *Phot. Sci. & Eng., 4:* 330–340, Nov.–Dec. 1960.

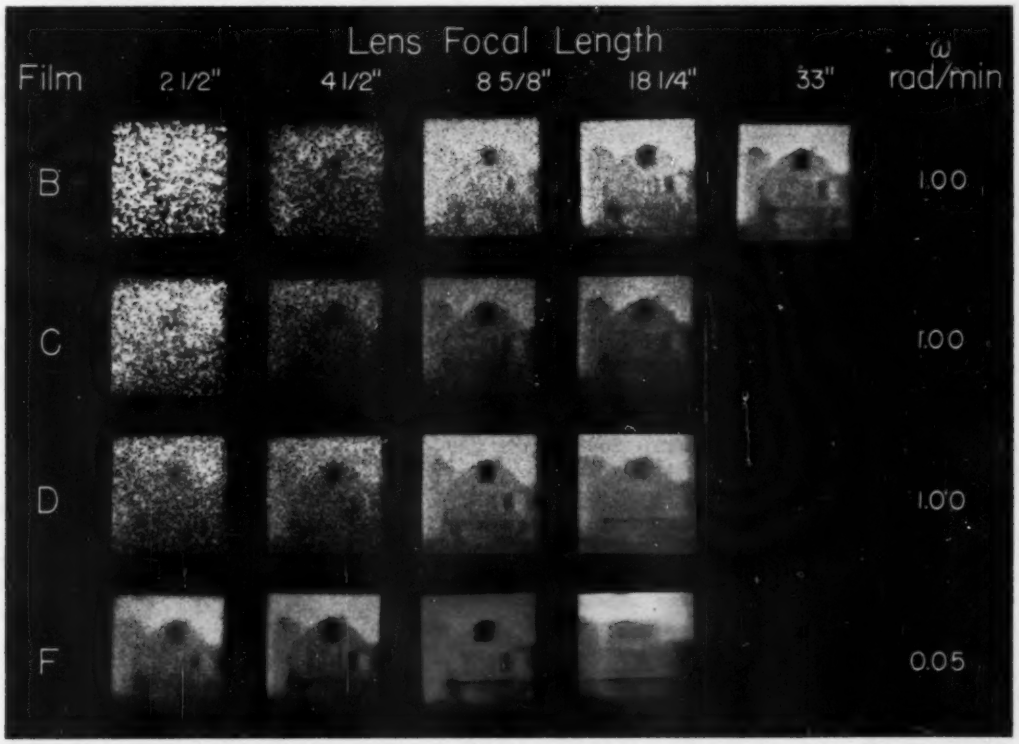


Fig. 17. Display of photographs corresponding to Fig. 15 but with the camera moving at the indicated angular speeds with respect to the scene. Note that, as the focal length of the camera lens increases, detail rendition passes through an optimum.

Ed. Note: The Fifth International Congress on High-Speed Photography was sponsored by the SMPTE and supported in part by the Departments of Army, Navy and Air Force through a grant administered by the Chief Signal Officer of the Army. Congress papers and related discussion will be published in the *Proceedings* of the Congress.

A Kerr-Cell Camera With Synchronized Light Source for Millimicrosecond Reflected Light Photography

By GEORGE A. THEOPHANIS

Certain events which can be studied photographically have associated with them a high degree of self-luminosity. To study the surface phenomena of these events, a high resolution, 50-mμsec Kerr cell camera and synchronized light source have been developed. A three-polarizer Kerr cell, having an optical transmission ratio of better than 10^6:1, is employed to prevent undesired exposure of the film due to the relatively long duration light from the self-luminosity which would bleed through a standard two-polarizer cell when closed. The cell is activated by means of a transmission line pulse generator capable of producing a 60,000-v square-wave pulse.

The light source consists of three commercial xenon filled flash-tubes which are energized by means of a hydrogen thyratron pulser. A transmission line network is incorporated into the flashtube pulser to produce a high-voltage synchronizing pulse when the flashtubes are ignited. This pulse is applied, via a length of delay cable, to the trigger electrode of the spark-gap switch which activates the Kerr cell shutter. Synchronization is accomplished with an accuracy of 5 mμsec. The camera has been used to photograph the early stages of electrically exploded metal foils, and hypervelocity impacts in a ballistics range.

Introduction

Kerr cells have been used for several years as submicrosecond photographic shutters. A great deal of information on this subject can be found in the literature, including the proceedings of past International Congresses.[1–4] It is noted in the literature that the use of these extremely short duration Kerr-cell shutters has been largely limited to emitted light and back-lighted photography. There are several reasons for this. Emitted light photography is the least difficult since it does not require the use of a light source other than the event itself. The events are usually extremely brilliant, allowing small-aperture Kerr cells to be used. The only synchronization problem involved is that of timing the shutter to the event.

Back-lighted photography becomes more complex in that an external light source must be synchronized to the shutter. However, in most cases a small-aperture shutter can still be employed. This is especially true in shadowgraph and schlieren photography in which a small-dimensioned light source is utilized. If one wishes to discriminate against self-luminosity, geometric discrimination in the form of a telecentric stop placed at the image plane of the light source can be employed. Back-lighted photography using a broad light source has been greatly aided by the development of the argon flashbomb. Light availability here is not a serious problem since efficient use can be made of the high specific brightness existing over the large area of this light source.

The light available in reflected light photography is only that which is reflected from the subject; therefore, it is necessary to use as wide an aperture shutter as possible to obtain a usable field size. The existence of self-luminosity adds considerably to the problem since geometric discrimination cannot be used. Basically, the light source must be powerful enough to overpower the radiation emitted from the event. This can be accomplished by concentrating the discharge of energy into a short time, thus producing a short-duration, high-peak light flash. The self-luminosity also presents the problem of undesired exposure on the film due to light bleeding through the partially opaque, closed shutter. The phenomena to be described produce enough light to expose a film through a standard closed Kerr cell. It is necessary that the shutter be made opaque enough to prevent this unwanted exposure.

At Avco RAD we had been interested in photographing the surface phenomena of metal foils in the early stages of electrical explosion. It was necessary to employ high resolution, reflected-light photography to record the desired data.

The camera requirements for this type of photography, coupled with a need for high magnification, were beyond existing techniques. For instance, it was necessary to devise a Kerr-cell shutter with a wide aperture, a millimicrosecond exposure time, and a high opacity. Also, it was imperative that the shutter present as low an optical insertion loss as possible and not degrade the optical image. The light source had to be of extremely high peak intensity and distributed in such a manner that the proper lighting of irregular surfaces could be accomplished. In addition, it was necessary to effect synchronization of the shutter and the light source with an uncertainty in the millimicrosecond range because of the narrow peak of the light flash. The system to be described has fulfilled these requirements with a high degree of reliability.

Discussion

1. Kerr Cell Shutter

A determination of the shutter exposure time was made on the basis of the intensity of emitted light during the period of interest, and of the rapidity of the expected motion during the event. In the exploding foil study, the luminosity generated by the molten material had to be considered since only the phases of explosion just

Presented on October 18, 1960, at the Fifth International Congress on High-Speed Photography in Washington, D.C., by George A. Theophanis, Avco Research and Advanced Development Div., Wilmington, Mass.

prior to vaporization were of interest. Fortunately, this luminosity was considerably lower than that resulting from the vaporization process. Peak velocities of surface deformations were expected to be in the order of 0.1 mm/μsec. The resultant exposure time chosen was 50 mμsec. The requirement of high opacity during the off-exposure time, which was necessitated by the presence of intense luminosity during the vaporization and re-strike phases of the event, plus the desire for low optical insertion loss during the exposure time, dictated the use of a shutter with an open-to-closed transmission ratio higher than found in simple Kerr cells using standard sheet polarizing material. This problem was further aggravated since it was intended to use high-speed panchromatic films which have a wide latitude of exposure from threshold to optimum.

For increased transmission ratio, a three-polarizer Kerr-cell shutter was employed. The shutter was, effectively, two cells in optical series using a common middle polarizer. Figure 1 is a photograph of the shutter in its housing with two rotatable polarizers. The transmission ratio for a spark light source was measured at better than 10^6:1. The insertion loss was equivalent to a density of about 1.4. The aperture was 1.25 in., and the overall distance between limiting apertures was 5 in.

A transmission line pulse generator[5,6] was employed to deliver a 60,000-v pulse to the cell. It was necessary to maintain a low source impedance in the pulse generator to achieve the short exposure time since the Kerr cell represented a capacitive load of about 100 $\mu\mu$f. A diagram of this pulse generator is shown in Fig. 2. Two cables in parallel were used to decrease the effective characteristic impedance Z_0, minimizing the charge time of the Kerr cell, and thus decreasing the rise and decay time of the transmission waveform. The load resistor R_L was a low multiple of Z_0. This mismatch was chosen to obtain as high a voltage amplification as possible without increasing the after-pulsing amplitude to a point where the shutter would be opened a second or third time. A "trigatron"[7] type of spark-gap switch was used to short circuit the cables. The resulting Kerr-cell transmission waveform, as observed with a photomultiplier and high-speed oscilloscope, was a 50-mμsec square wave.

2. Light Source

The basic requirements of the light source were that it be broad in area and that it be sufficiently intense that the light flux reflected from a unit area of the sample surface be great enough to expose the film during the recording time. The shiny metal surfaces of the samples posed a special problem in proper lighting. It was necessary to distribute the source in space to avoid too high a contrast in the resulting photographs. The light source

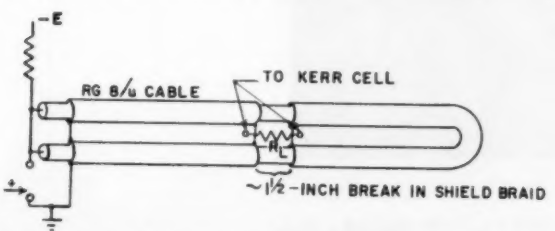


Fig. 2. Diagram of Kerr-cell pulse generator.

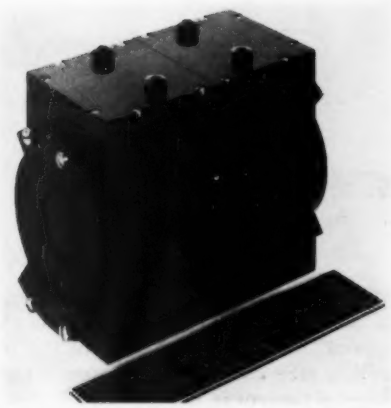


Fig. 1. Three-polarizer Kerr-cell shutter.

chosen was a series of three xenon-filled flashtubes activated by a hydrogen thyratron pulser. The light source assemblies were grouped around the camera lens as closely as possible, with light to camera angles of 30–40°. Minor adjustments in position were made by making test exposures of wrinkled aluminum foil surfaces.

A schematic diagram of the pulser is shown in Fig. 3. The energy was stored in the three separate capacitors C_1, C_2, and C_3 to ensure an equal distribution of energy to the three flashtubes. The three capacitors were simultaneously discharged through a single 5C22 hydrogen thyratron. The value of the capacitors was 0.05 μf; thus, at 16,000 v the energy stored for each flashtube was 6.4 joules. The total integrated duration of the three lamps was about 0.5 μsec.

3. Synchronization

Synchronization was a twofold problem of timing the camera to the event and of synchronizing the Kerr-cell opening to the light peak. Although the experiment described here did not require a timing accuracy greater than 0.1 μsec, millimicrosecond accuracy was provided for future use in which photographs could be correlated in time to measurements of other parameters. This millimicrosecond accuracy was inherent in the hydrogen thyratron which triggered the camera, if an appropriate pulse were derived from the event. Synchronization of the Kerr cell with the light source was a more difficult task. The accuracy needed was in the millimicrosecond range, because of the narrow peak of the light pulse. Triggering of the trigatron with such accuracy could not be accomplished with the usual type of trigger generator utilizing a pulse transformer.[8] This was true because the triggering pulse must have a rise time no greater than

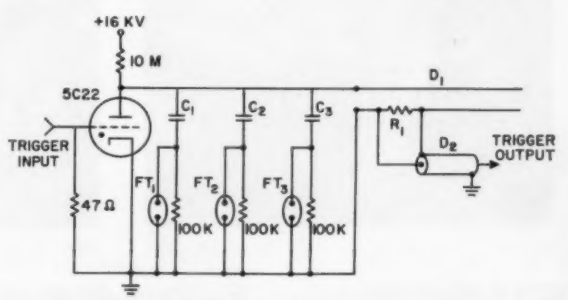


Fig. 3. Synchronized flashtube pulser.

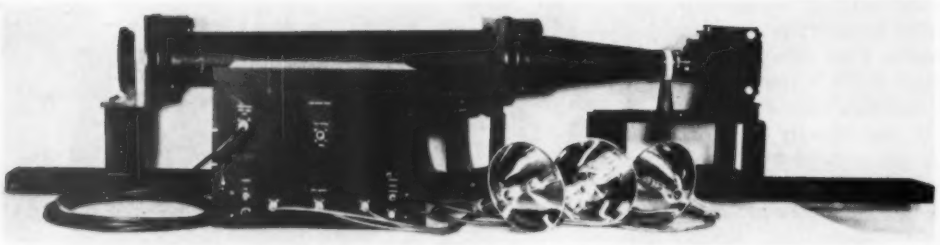


Fig. 4. Kerr-cell camera and light source.

the jitter time desired. Conventional pulse transformers could not respond to the millimicrosecond times required. Also, the inductance of the transformer in the switch tube circuit would cause a lag in the establishment of current in the gas. This would result in delayed, unreliable switching.

The network to the right of C_3 in Fig. 3 is a cable pulse generator which was actuated by the 5C22 thyratron at the same time that C_1, C_2 and C_3 were discharged. A pulse of 30,000-v amplitude and a few millimicroseconds rise time was produced across R_1. This pulse was transmitted by D_2, a delay cable, to the trigger electrode of the trigatron gap in the Kerr-cell pulse generator. This gap was a three-electrode arrangement with the trigger electrode coaxial with the anode. The whole assembly was immersed in an atmosphere of insulating gas to limit corona and reduce the discharge inductance. Triggering was accomplished with a jitter time of 5 mμsec over a 10% range of potential across the gap. The polarity of the trigger pulse was made positive, thus enhancing the field in the gap sufficiently to draw electrons from the cathode and initiate the avalanche. This technique proved very reliable. Synchronization never failed throughout the 200 photographs taken.

4. Optics

A relay lens system was employed because of the short focal length of the camera lens (4 in.) and the violent nature of the event. The complete system, excluding the Kerr-cell pulse generator, is pictured in Fig. 4. A camera back containing a focal plane shutter was used as the film holder and capping shutter. The Kerr cell was placed directly in front of the capping shutter and completely filled the space up to the camera lens.

The system was set for a fixed focus of 18 in. with a magnification on the film plane of 0.5. The maximum effective geometrical aperture was $f/2.5$. Including the insertion loss of the Kerr cell the maximum total effective aperture was $f/14$. The field size at the object plane was slightly over 2 in. This could be increased by using a wider aperture shutter.

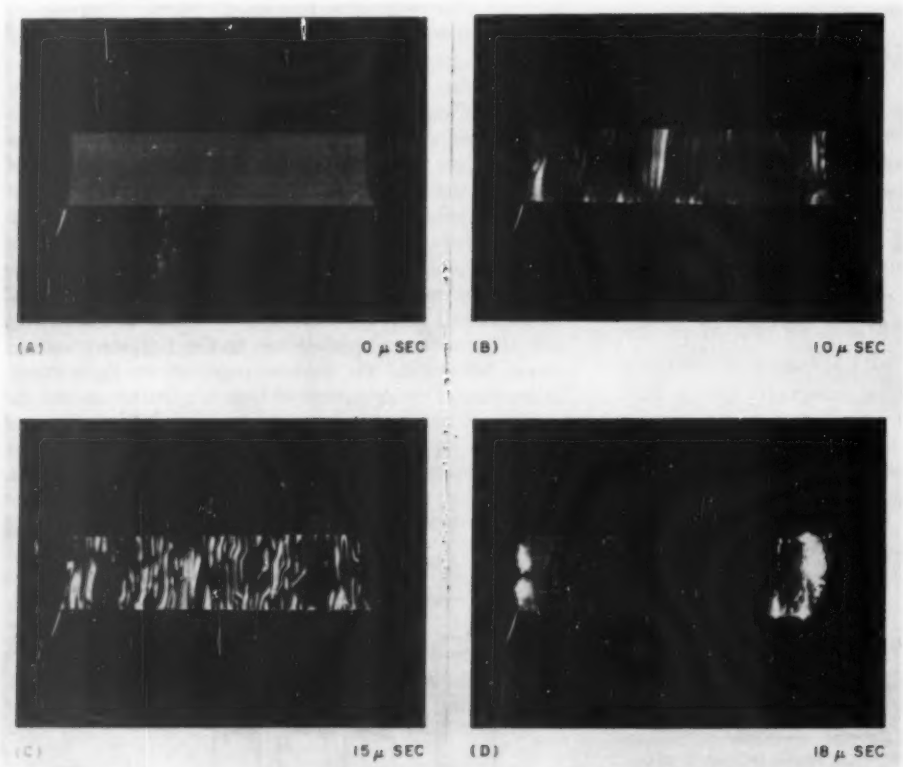


Fig. 5. Reflected light photographs of electrically exploded 0.001 in. thick brass foil. Exposure times 0.05 μsec.

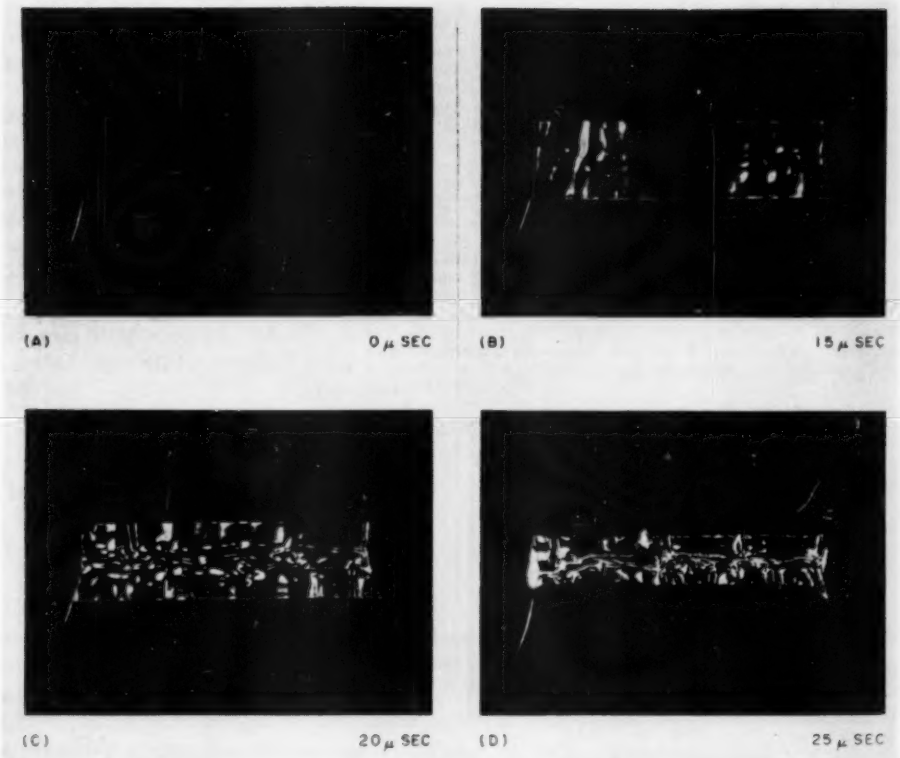


Fig. 6. Reflected light photographs of electrically exploded 0.0017 in. thick aluminum foil. Exposure times 0.05 μsec.

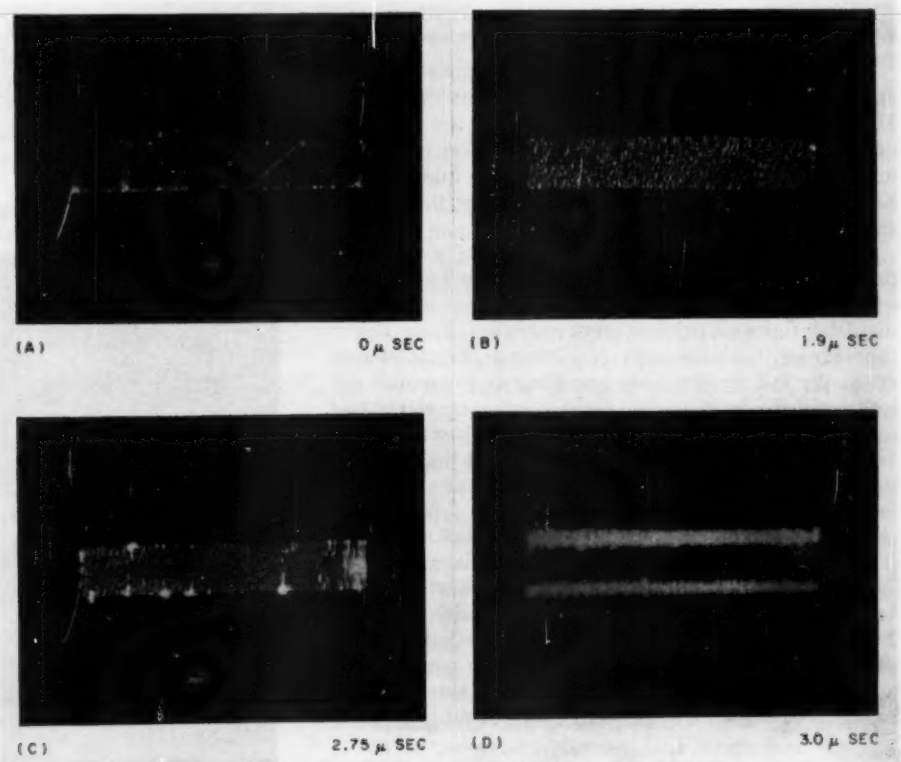


Fig. 7. Reflected light photographs of electrically exploded 0.0002 in. thick aluminum foil. Exposure times 0.05 μsec.

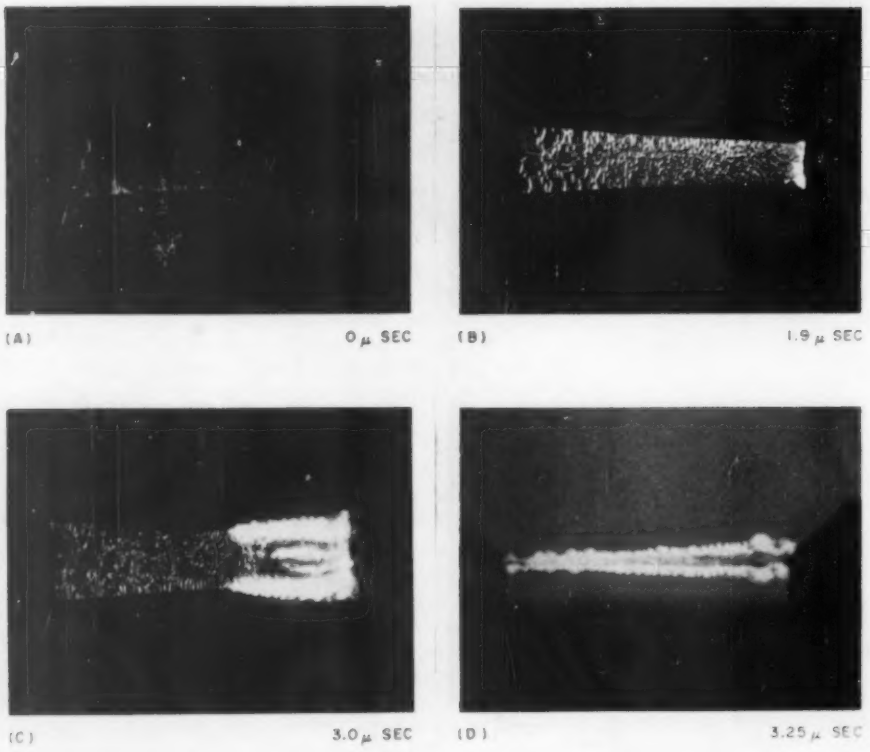


Fig. 8. Reflected light photographs of electrically exploded tapered 0.0002 in. thick aluminum foil and back lighted, edge-on view. Exposure times 0.05 μsec.

Results

The camera was stopped down to a total effective aperture of *f*/56 while taking the photographs shown in Figs. 5–8. This indicates that the camera is capable of taking reflected light photographs of surfaces of similar reflectivity at exposure times as short as 5 mμsec. Such Kerr-cell exposure times are now within the state of the art of high-speed photography.[9,10]

Figure 5 is a sequence of photographs of a 0.001-in. thick brass foil. The foil was 1.0-in. long by 0.25-in. wide. A separate foil was used for each exposure, with the delay times set prior to every explosion. These delay times are indicated below the photographs. This sequence shows the foil progressively wrinkling as it expands on heating in the rigid holder. The last exposure shows the wrinkles suddenly relieved in the molten phase. A slight amount of vaporization can be observed at the extremities of the foil. Figure 6 is a similar sequence of a 0.00175-in. aluminum foil. Here wrinkling can be observed to be occurring both transversely and longitudinally with respect to the axis. In Fig. 7, where 0.0002-in. aluminum foil was used, the size of the wrinkles was much smaller. It is difficult to detect a molten phase with this foil. In Fig. 8, a tapered 0.0002-in. aluminum foil was exploded in an attempt to observe a molten zone. There appears to be some disruption of the wrinkled surface in the third exposure in the area bounded on three sides by vaporization. The last exposure in this series is a backlighted edge-on view of the foil.

The camera has also been used to photograph impacts on a hypervelocity terminal ballistics range. An example of the results is shown in Fig. 9. This is a 45° view of the back side of an aluminum target being pierced by a 4000-ft/sec projectile. Only two light sources were used here and the effective aperture was *f*/28.

Fig. 9. Reflected light photograph of back side of 0.062 in. aluminum target pierced by 4000 ft/sec projectile. Exposure time. 0.05 μsec.

Conclusions

The camera presented here has surmounted several existing problems associated with millimicrosecond reflected light photography. This system has made possible high-resolution, high-magnification photography of phenomena occurring in a large field. In addition, self-luminosity has been effectively suppressed by the use of a Kerr-cell shutter having a high opacity ratio. The results indicate that the capabilities of this camera can be further exploited to increase magnification and to shorten exposure time.

Acknowledgments: This work was supported by the United States Air Force. The author expresses his thanks to J. A. Hull for his valuable aid.

References

1. High-Speed Photography, Reprint Vols. 1–6, Society of Motion Picture and Television Engineers, 1948–1957.
2. *Proc. 2nd International Congress on High-Speed Photography*, Dunod, 92 rue Bonaparte, Paris 6, 1956.
3. *Proc. 3rd International Congress on High-Speed Photography*, Butterworths Publications, Ltd. 88 Kingsway, London W.C.2; in U. S. by Academic Press Inc., 111 Fifth Ave., New York 3, 1956.
4. J. S. Courtney-Pratt, *Reports on Progress in Physics, 20:* 397–432, 1957.
5. J. A. Hull, "A technique for obtaining submicrosecond exposure times at large aperture in high-speed photography," Univ. of New Mexico, M.S.E.E. Thesis, 1956.
6. J. A. Hull, *IRE National Convention Record, Part 5:* 228, 1958.
7. J. D. Craggs, M. E. Haine and J. M. Meek, *Jour. Inst. Elec. Engrs.*, IIIA, *93,* 963–976, London, 1946.
8. G. A. Theophanis, *Rev. Sci. Instr., 31:* 427–432, 1960.
9. J. A. Hull and G. A. Theophanis, "Ballistics-range applications of millimicrosecond photography," *Jour. SMPTE, 69:*355–357, May 1960.
10. A. M. Zarem, F. R. Marshal and S. M. Hauser, *Rev. Sci. Instr., 29:* 1041–1044, 1958.

Electronic Image Intensification:

Image Intensifier Using Cathodo-Conductivity

By R. A. CHIPPENDALE and J. R. FOLKES

Recent work on an electron microscope image intensifier has established that thin films of amorphous selenium can give charge multiplication in the region of 2000 when bombarded with high energy electrons. A sealed-off tube achieving prescanning amplification in a similar selenium film is described.

In the "writing" function, electrons from a semitransparent photoemissive cathode are focused and accelerated into a 10-μ self-supporting selenium film. The provision of an electron transparent signal plate on the front surface of the film enables charges to be driven to the rear whence they are removed by a low-voltage scanning beam which returns the surface to reading gun cathode potential. Electrostatic scanning is used in combination with retarding field electrodes to achieve orthogonality.

Overall sensitivity is dependent on both photo-cathode efficiency and charge multiplication in the selenium — which is itself a function of the writing electron voltage. It can be shown theoretically that the use of a suitably restricted bandwidth and optimized amplifier conditions should enable single photoelectrons to be detected. Tests on experimental tubes have shown that prescanning gains of 500 should be practicable. In this case the tube should be capable of detecting 40 incident photons per cathode image point per frame.

IMAGE TUBES have become widely used in many applications involving the recording of transient optical phenomena. The majority of tubes using photoemissive cathodes to detect the primary radiation fall into two classes: (a) tubes with optical output, e.g. image converters; and (b) signal generating tubes, e.g. television cameras.

In the present context considerable development and application work has been done on devices in group (a), some of which have reached an advanced stage. The cascade image converter[1] and the multistage knock on secondary emission image tube[2,3] are both stated to be cathode quantum limited.

The sensitivity of the image orthicon which is representative of the most advanced type in group (b) is, however, limited by noise generated by the scanning beam. In order to take full advantage of the superior quantum efficiency of the photocathode over that of the photographic plate, the need for a relatively noise-free amplification, prior to scanning, is indicated. Decker and Schneeberger[4] have described an image tube in which prescanning amplification was achieved by cathodo-conductivity (bombardment induced conductivity) in As_2S_3 and have shown that an improvement in signal/noise, compared with the image orthicon, can be achieved.

Recent work on an electron microscope image intensifier,[5] which works in a demountable vacuum system, has resulted in the practical application of selenium layers giving charge amplifications of up to 2000. The success of this device, and in particular the stability of the selenium targets used, led us to investigate the possibilities of using the cathodo-conductive effect in selenium to achieve prescanning amplification in a sealed-off image tube.

Principle of the Pickup Tube

Figure 1 is a diagramatic outline of a tube incorporating a selenium target intensifying element. The "writing" function begins at the semitransparent photocathode H from which the electrons forming the primary image are accelerated by the electrostatic lens system G to penetrate the metallic signal plate F which is on the surface of a thin selenium film E. The "reading" section works on the vidicon principle. Electrons leaving gun A around 1 kv are focused and scanned by lens B and de-

Presented on October 18, 1960, at the Fifth International Congress on High-Speed Photography in Washington, D.C., by R. A. Chippendale (who read the paper) and J. R. Folkes, Associated Electrical Industries (Woolwich) Ltd., Harlow Research Laboratory, Templefields, Harlow, Essex, England.

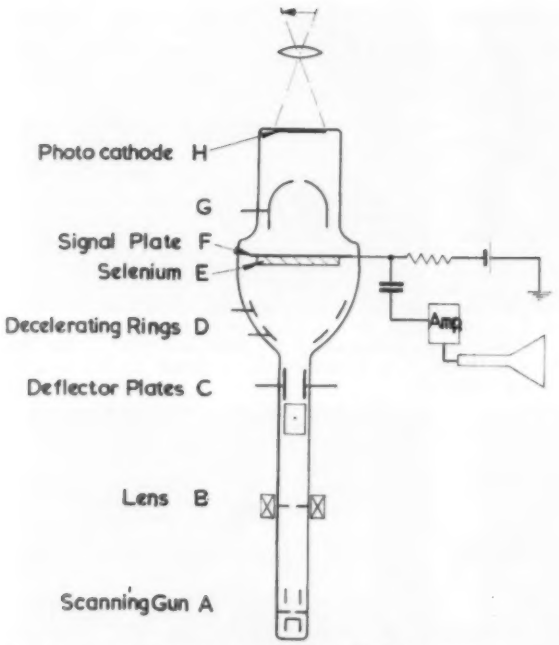


Fig. 1. Image tube using cathodo-conductivity in selenium.

flector plates C. The electron beam then enters a retarding field set up by electrodes D which ensure orthogonal approach to the selenium surface. The electron beam scans the surface of the selenium and stabilizes it at reading gun cathode potential. The signal plate F is at the same time held at $\sim +30$ volts thus establishing a field across the selenium.

High-voltage electrons from the photocathode bombarding the selenium result in a charge multiplication and a conduction current which partially discharges the layer leaving the image charge pattern on the reading surface of the selenium.

The next scan of the reading beam returns the surface to cathode potential and generates the picture signal which is led out via the signal plate, amplified and displayed on a cathode-ray tube, or otherwise recorded.

Physical Properties of Selenium

Amorphous selenium has a dark resistivity in excess of 10^{16} ohm-cm. It is unstable at elevated temperatures and a transformation to a crystalline form begins at temperatures variously reported as between 30 and 80 C. Recrystallisation is accompanied by a drop in resistivity to $\sim 10^{9}$ ohm-cm. The bulk material melts at 217 C and can be readily evaporated for vacuum deposition.

Cathodo-Conductivity

A suitably prepared layer of amorphous selenium exhibits a marked cathodo-conductive effect.[6,7] The impact of a single high-voltage electron can create a shower of charge carriers which are sufficiently mobile under the influence of an electric field to permit current flow through the layer.

The selenium targets used in the electron microscope were supported by a plastic membrane which was easily penetrated by the high-energy electrons (50 to 100 kv) before entering the selenium. In sealed-off image tubes, however, it is difficult to attain stable operation with

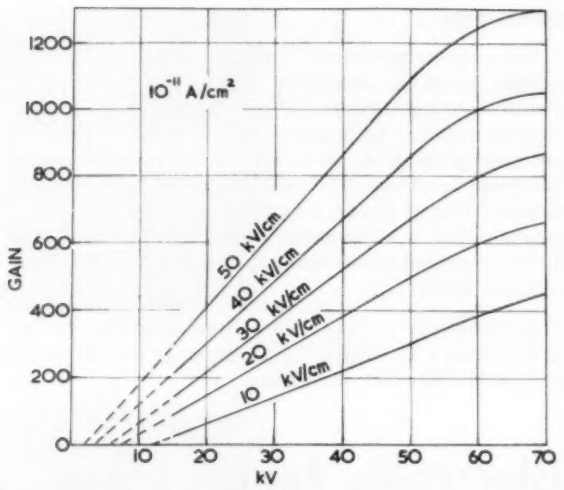


Fig. 2. Variation of gain with writing voltage in an 18-micron self-supporting selenium layer; writing current = 10^{-11} amp/cm²; the figures of kv/cm refer to field applied across the selenium layer, i.e. between cathode potential stabilized Se surface and signal plate.

photoelectron accelerating voltages in excess of 25 kv; and at these, or lower voltages, excessive electron energy would be lost in penetrating the supporting membrane. For this reason self-supporting layers are being used.

Figure 2 shows the variation of cathodo-conductive gain with primary electron energy in an 18-micron selenium target for several values of applied electric field. (The gain is given by the ratio of the induced current to the irradiating beam current.) In practice, the field across the layer usually has to be limited to 20 kv/cm in order to avoid the generation of bright spots due to local breakdown of insulating properties. Some layers are better than others in this respect; and it is hoped that better control of preparation techniques will eventually permit the use of higher field strengths. Measurements of gain vs. layer thickness are not yet complete but indications are that for 15 to 20-kv writing there is no advantage in using layers thinner than 18 microns.

Theoretical Limitations

In order to estimate the limiting sensitivity of such a tube it is convenient to consider a single picture point element. Since the quantum sensitivity of the photocathode is less than one, the basic quantum noise will be determined by the number of electrons emitted into one image point area during an exposure. If this number is N_e the absolute quantum noise will be $\sqrt{N_e}$ and the fractional quantum noise $1/\sqrt{N_e}$. Thus the minimum contrast observable will be some factor say $5 \times (1/\sqrt{N_e})$

The fractional quantum noise will increase as N_e gets smaller but not so fast as the signal decreases; so that eventually a further limitation will be imposed by amplifier noise. The limiting sensitivity of the tube can be defined by the value of N_e at which the quantum noise equals the amplifier noise.

If we consider a limiting condition when the noise of an optimized amplifier is less than the quantum noise by a factor 2, it can be shown that the number of photoelectrons required per picture point is given by:

$$N_e = 4.8 \times 10^{18} C^2 R_e \frac{\Delta f}{G^2}$$

where C is the total input capacity of the amplifier, R_e the equivalent noise resistance, Δf the bandwidth and G the gain in the selenium layer.* For a value of C = 20 $\mu\mu$f, and R_e = 1000 ohm, the number of photons required per image point $N_p = 200\ \Delta f/G^2$.

If we now assume a value of G = 200 and $\Delta f = 10^6$c/sec, we get N_p = 5000. This means that working at TV frequencies, 5000 photons per picture point would be detected with an image quantum noise of 1.4%. Slower scanning rates and smaller bandwidths can be seen to give increased sensitivity. Moreover, their use is practicable as charges can be stored for long periods on a good selenium layer.

If we assume a value of G = 500 and $\Delta f = 10^4$c/sec and again, a value of R_e = 1000 ohm, the limiting condition is given by N_p = 10, i.e. detection of 10 incident photons per image point.

Tube Technology

Figure 3 shows the glass-metal construction used (C40 – Nilo K).† Annular metal rings and flanges support the electrodes in the writing section. The use of a large-diameter joining flange permits the insertion of electrodes before final vacuum sealing by argon arc welding.

The Selenium Target

In order to achieve a high vacuum in a sealed-off tube, a prolonged high-temperature bake is required on the pump. As normal baking temperatures are above 350 C, selenium, which melts at 217 C, cannot be present. Two methods of including a selenium target seem possible: (a) to evaporate *in situ*, onto a suitable electron transparent membrane after the bake out; or (b) to insert a preformed target assembly into the tube after bake-out without disturbing the vacuum conditions.

Method (a) presents two difficulties: first, the existence of a support membrane is undesirable as it absorbs energy from the writing electrons; and second, evaporation of selenium in the tube coats other electrodes with an insulating layer unless preventative measures can be found. We have adopted method (b). A prefabricated target assembly is stored in a cool portion of a length of rectangular cross-section tubing (internal dimensions 4mm × 46mm) sealed to the main body of the tube and projecting well outside the oven. The target is subsequently pushed along the tubing and into position by means of a magnetic slug which is withdrawn prior to sealing off the projecting tubing.

The target assembly is made up of two rectangular stainless-steel frames between which the selenium layer is fixed by a suitable adhesive. Selenium films down to 8-microns thick mounted this way are surprisingly robust and stand up to normal handling. The 2 cm by 2 cm signal plate, lead-off strip and contact pin can be seen in Fig. 4. Contact to the signal plate is made via a spring which slides over the pin when the target assembly is slid into its holder in the tube.

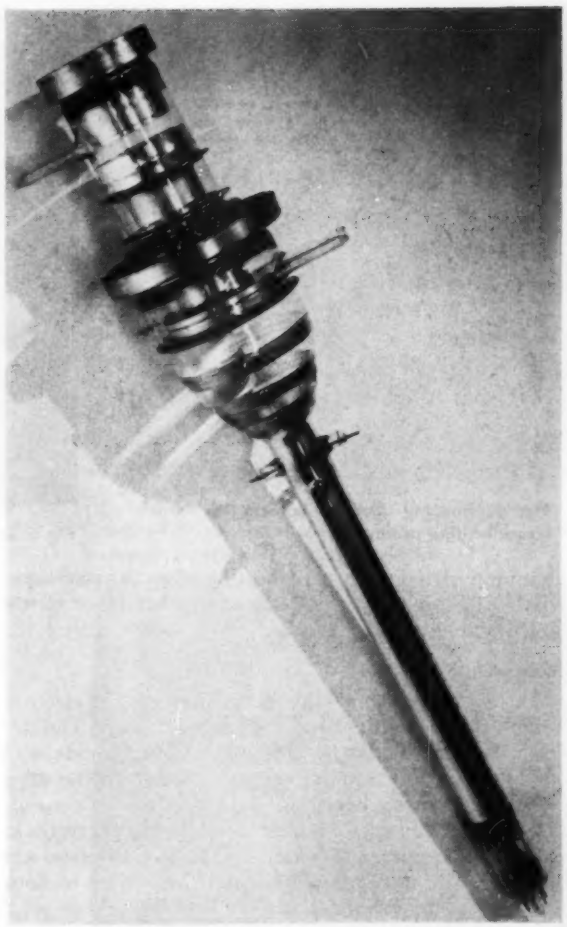


Fig. 3. Experimental intensifier tube.

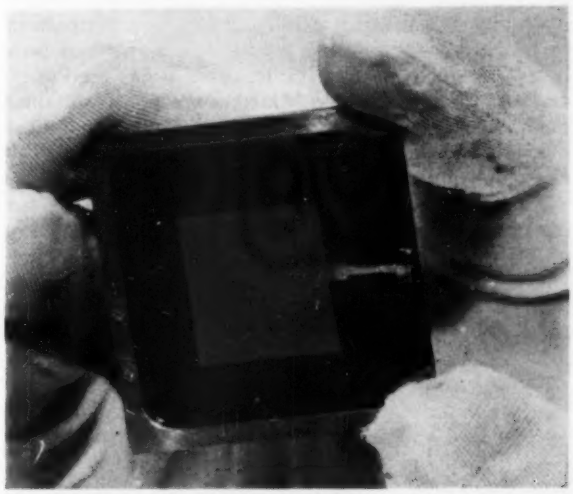


Fig. 4. Self-supporting selenium target.

The process of forming a satisfactory selenium film is very critical as small variations in conditions can result in large differences in resistivity in the target. We have had reasonable success by evaporating selenium onto a cooled (−20 C) aluminum foil which can be removed in HCl. During the subsequent vacuum deposition of the

* An analysis of the writing/reading function by Haine et al. will be given in *Proc. I.E.E.* shortly.

† C4O is a Kovar sealing borosilicate glass [expansion coefficient 48 × 10^{-7} (20 – 350 C)] manufactured by A.E.I. Ltd., Chesterfield, England. Nilo K is a Ni Co Fe alloy for sealing to medium hard glasses manufactured by Henry Wiggin and Co., Birmingham, England.

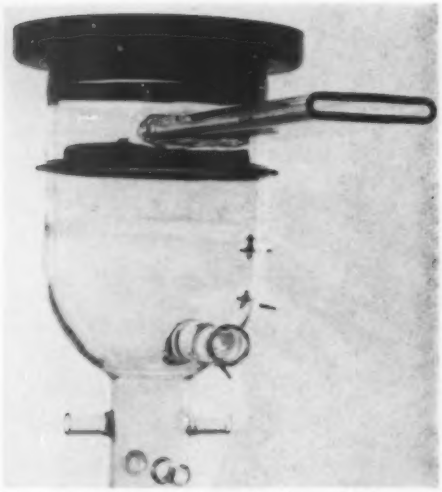


Fig. 5. Reading section showing selenium target loading tube.

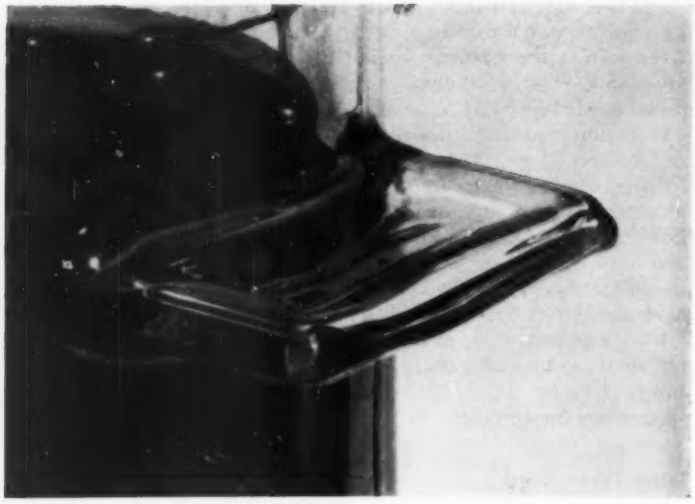


Fig. 6. Seal off on rectangular glass tubing.

aluminum signal plate, care must be taken to avoid overheating the film, as this can cause low resistance effects and partial recrystallization.

The Reading Section

This is based on, and is almost identical to, the electron microscope intensifier system used by Haine. The decelerating ring electrodes (Fig. 3) and final anode wall coating are of aluminum, vacuum coated on the glass envelope, leadouts being via Nilo K pins. A conventional CRT tetrode gun is used with limiting apertures in both second anode and lens. The deflection plates are jig-mounted and supported on their individual leadout pins sealed through the glass.

The Writing Section (Image Converter)

To date, the main requirement has been the provision of an image converter capable of use with a test pattern to provide image-forming photoelectrons for test purposes. A single electrostatic lens system has been used, and a SbCs photocathode formed *in situ* by conventional methods. This system works with an electron optical demagnification of 0.7 and gives a resolution of > 10 line pairs/mm at the selenium target.

In order to achieve maximum sensitivity, however, the use of a multi-alkali cathode[8] is indicated in some cases and always with the maximum possible accelerating voltage. For this reason a new cathode-forming technique is being developed. A multi-alkali surface is prepared on a glass plate in an appendage to the main tube and slid into position via a rectangular tubing similar to that used for the selenium target. In this way contamination of tube components by the alkali vapor is avoided and operating voltages thereby increased. To date the highest sensitivity achieved in a sealed-off photocell using a cathode of this type is 80 μamp/lm. Difficulty has been experienced with the adverse effects of gases released on sealing off the rectangular tubing (H_2O CO CO_2 O_2 Cl_2) but recent modifications of technique have largely eliminated this trouble.

Glass Technology

The fabrication and effective use of narrow slot section glass tubing by our Glass Shop has been the biggest single contribution to the technology of the device. Methods have been evolved for joining lengths of tubing, sealing to the required tube envelope and for sealing off under vacuum. Figure 5 shows the body of a reading section with a selenium target loading tube in position. This cross section has circular ends and is stronger than shapes nearer to rectangular. The tubing illustrated (46 mm by 4.0 mm, 2.5-mm wall) has been satisfactorily pressure tested up to 40 psi. Figure 6 shows a typical rectangular tubing seal-off projecting 25 mm from the body of an image tube. The seal-off is done with a conventional oxy-gas hand lamp.

Experimental Results

The quality of the selenium layer is obviously vital to the overall performance of a sealed-off tube. It is fortunate that layers are stable in air and remain relatively "clean" if handled with care. This enables the target assembly to be tested before insertion into a tube.

First tests on self-supporting layers were carried out in an electron microscope with encouraging results. Working at normal British TV standards (405-line, 50-frames/sec, 3-mc bandwidth) the layers were free from blemishes and gave good picture quality at writing currents of the order of 10^{-12} amp/cm^2 (50 kv). A typical layer of this type was found to have a resistivity of the order of 5×10^{14} ohm-cm. When used in a sealed-off tube and discharged with a 20-sec reading scan,‡ large spurious signals were generated in the dark. (Fig. 7c). This was due to uneven leakage currents through the layer. Dark current gain and storage are now being measured in a continuously pumped demountable tube which simulates the sealed-off device in all respects except that the pressure is higher (down to 10^{-6} mm Hg). Recent layers have had resistivities of $> 10^{16}$ ohm-cm and appear to be capable of storing charges for periods of at least one hour without generating obtrusive leakage signals.

A few complete tubes have been processed with SbCs cathodes formed internally by means of a conventional withdrawal evaporator. These have so far fallen far

‡ $\Delta f = 10^4$ c/sec. The scanning rate and amplifier characteristics have been chosen for best detection sensitivity.

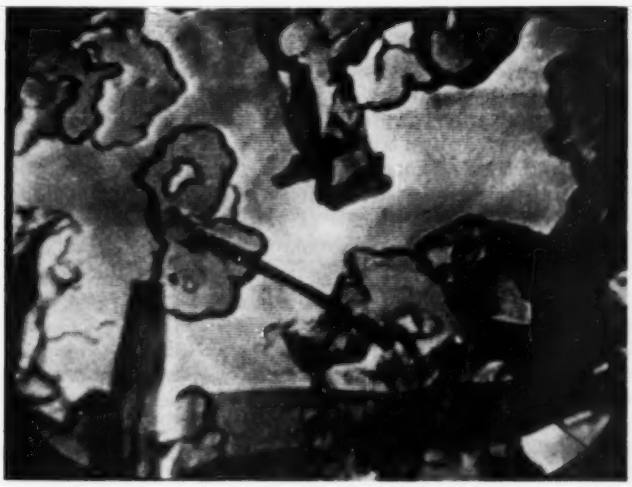


Fig. 7(a). Typical electron microscope image, replica of cabbage leaf. Overall magnification to 14 in., monitor screen 5 × 10^5; writing at 50 kv, 10^{-12} amp/cm²; reading at 405 lines, 50 fields/sec; Se layer resistance, 10^{14} ohm-cm.

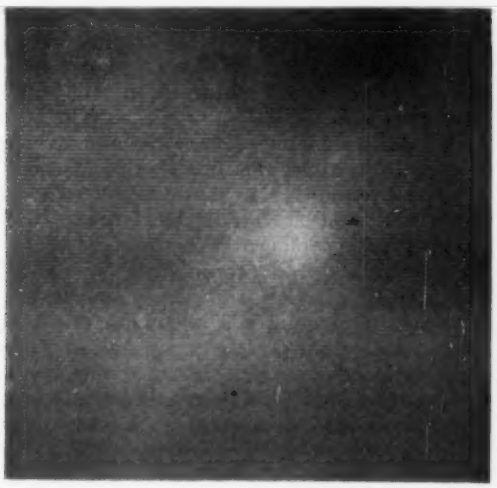


Fig. 7(b). Se layer 18-micron thick, self-supporting. Resistivity 10^{14} ohm-cm; writing uniform at 50 kv, 10^{-11} amp/cm²; reading at 405 lines, 50 fields/sec.

short of optimum performance, particularly with respect to the cathode sensitivity, but have served to show that the tube is practicable and that experience in processing should enable cathodes of 50 to 60 μamp/cm² to be achieved with good selenium layers and reading gun performance. Cold emission in the writing section due to alkali vapor contaminated electrodes has limited operating voltages to from 8 kv to 14 kv. This could probably be improved by control in processing, but the external formation of the cathode (or the rotating cathode plate of McGee[9]) will be needed to get substantially higher voltages. We have not yet succeeded in loading a maximum sensitivity cathode into a complete tube which has all other components also of top quality. Our experience on photocells with multi-alkali cathodes introduced in this way indicates that this should be practicable. A sensitivity of > 100 μamp/lm with a dark emission of < 10^{16} amp/cm² at 20 C, appears possible.

The electrostatic lens system sets the present limit to resolution. A 400-line raster is being used for test purposes but the reading tube is capable of 800-line operation. A magnetically focused image section would probably be required to take advantage of this. Practical measurements of minimum light levels for recording have not been made. These will await the incorporation of a writing section capable of stable high voltage working without spurious signals.

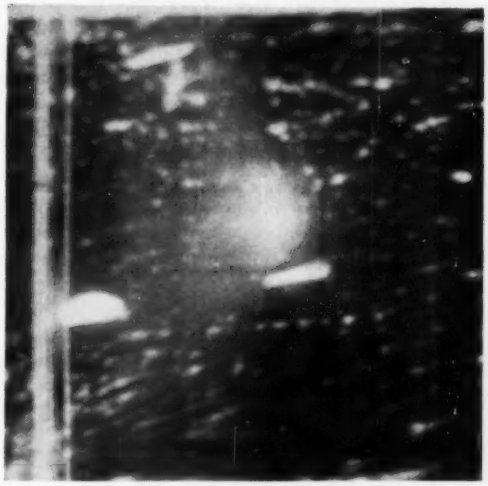


Fig. 7(c). Se layer 18-micron thick, self-supporting. Resistivity 10^{14} ohm-cm; no writing; uniform field 20 kv/cm established across the layer. Showing signals generated by uneven layer discharge (internal); reading, single 400-line scan lasting 20 sec.

Discussion

The various techniques necessary for the use of a cathodo-conductive target in an image tube have been proved. Although many refinements will be necessary to ensure optimum performance, we might consider the tube requirements for one or two types of application, and estimate the likely practical results for: (1) short (< 10^{-7}-sec) exposures where it is desired to use the

Fig. 7(d). Se layer 18-micron thick, self-supporting. Resistivity > 10^{16} ohm-cm. No writing; layer field 20 kv/cm established; reading 15 min later by a single scan taking 20 sec to cover the target. No spurious discharge signals generated.

writing section as an electronic shutter; and (2) long exposures with low-intensity low-contrast images.

For the first application the image converter section described by Butslov[1] appears ideal. Here switching is effected by the application of relatively low voltages to low-capacity scanning plates. High-speed image scanning is also possible. For single-shot high-speed recordings, however, fairly simple image converters will suffice provided that one accepts the difficulties of pulsing at the full accelerating voltage. Pulse voltages can be applied (provided that their duration is of the order of 10^{-7} sec or less), greatly in excess of the maximum steady voltage for stable operation. It is reasonable to expect, therefore, that a writing electron voltage of 30 kv could be used in certain cases. At this voltage a cathodo-conductive gain of 250, has been shown to be practicable. Even a gain of 500 is workable with some loss in picture quality (white spots). Under these conditions the device should be quantum limited at the cathode. It should be pointed out that a writing current density of the order of 10^{-7} amp would be required to transfer a charge corresponding to an average image in 10^{-7} sec; and that gain measurements, at these current densities and under pulse conditions, have not been carried out.

The second type of application is typified by the problem of recording a star image that is only fractionally brighter than the surrounding sky (e.g. a star image of 0.01-cm diameter with an intensity of 10^6 photons/cm^2/sec superimposed on a sky background of 5×10^6 photons/cm^2/sec).

If we accept a 2% quantum noise it will be necessary to store 2500 photoelectrons per image point (25,000 incident photons). Photons arrive in the star image at 450/sec and an integration time of 50 sec would therefore be required. It can also be seen [from $N_p = (200\Delta f/G^2)$] that a cathodo-conductive gain of the order of only 9 would be required. This would permit lower voltage operation of the writing section ($\sim$8 kv). This in turn eases the problem of spurious signals in an image converter which is on, of necessity, for long periods.

The performance of recent selenium layers, particularly in respect to stability, charge storage and cathodo-conductive gain, leads us to believe that their use in tubes will be of value to many such recording problems. This is particularly so where the provision of the recorded data in the form of a video signal can be accepted or regarded as an advantage.

Acknowledgments: The authors wish to acknowledge financial assistance from: The Carnegie Institute of Washington; C.E.R.N., Geneva; and the U.K. Atomic Weapons Research Establishment. The authors are also indebted to their colleagues who are engaged on this project, in particular to J. T. Balkwill for glass techniques, and to M. E. Haine for guidance and encouragement.

References

1. M. M. Butslov et al., *Proc. 4th International Congress on High-Speed Photography*, Verlag Dr. Othmar Helwich, Hoffmannstr. 59, Darmstadt, Germany, 1959.
2. W. L. Wilcock, D. L. Emberson and B. Weekley, *Nature 185:* 370, 1960.
3. M. M. Wachtel, et al., "Image intensification by transmission secondary electron emission," *Rev. Sci. Inst.:* 576, 1960.
4. R. W. Decker and R. J. Schneeberger, "Image tube utilizing bombardment induced conductivity," *IRE Nat. Convention Record, Part 3:* 1957.
5. M. E. Haine and P. A. Einstein, "Image intensifier," *Proc. European Regional Conference on Electron Microscopy*, Delft, 1960.
6. L. Pensak, *Phys. Rev., 79:* 171, 1950.
7. W. E. Spear, *Proc. Phys. Soc., B69:* 1139, 1956.
8. Sommer, "Multi alkali cathode," *Rev. Sci. Instr., 26:* 725, 1955.
9. J. D. McGee, *Proc. of the Image Intensifier Symposium*, Fort Belvoir, Oct. 1958.

Ed. Note: The Fifth International Congress on High-Speed Photography was sponsored by the SMPTE and supported in part by the Departments of Army, Navy and Air Force through a grant administered by the Chief Signal Officer of the Army. Congress papers and related discussion will be published in the *Proceedings* of the Congress.

standards and recommended practices

Proposed American Standards

The proposals published here have been approved by the initiating and Standards Committees and are submitted for a three-month period of trial and comment:

PH22.127, Magnetic Coating of 16mm Magnetic-Photographic Sound Record, is basically SMPTE Recommended Practice RP 2. The Recommended Practice originated in the Magnetic Recording Subcommittee in April 1953. Due to lack of an industry-wide directive, it was considered unsuitable for processing as a standard and in May of 1955 was approved and published as an SMPTE Recommended Practice. In recent years, the accepted usage of this practice has resulted in a reevaluation by the Sound Committee at its May 1960 meeting. The members present agreed that it should now receive the status of an American Standard.

Inasmuch as the proposed revision of American Standard PH22.37-1944, reaffirmed 1953, Dimensions for Raw Stock Cores for 35mm Motion-Picture Film, represents a substantial modification from the 1953 reaffirmation both in dimensioning and in an additional descriptive appendix, it is suggested that interested parties be certain to examine both the 1953 reaffirmation published in the September 1946 Journal and the present proposal.

All comments should be addressed to Alex E. Alden, Staff Engineer, at Society Headquarters prior to October 15, 1961. If no adverse comments are received by that date, the proposals will be submitted to ASA Sectional Committee PH22 for further processing.

Approved American Standards

A new American Standard, PH22.124-1961, Screen Luminance for Indoor Theaters, was approved by the American Standards Association on May 5, 1961. This standard is substantially as published in the April 1960 Journal.

American Standard PH22.75-1953, A and B Windings of 16mm Film, Perforated One Edge, was reviewed by the 16 & 8mm and Standards Committees and was reaffirmed without change by the American Standards Association on April 21, 1961 as PH22.75-1953 R 1961. The standard was previously published in the February 1954 Journal.

On May 19, 1961, the American Standards Association approved revision of the following American Standards:

PH22.3-1961, 35mm Photographic Sound Motion-Picture Film, Usage in Projector (Revision of PH22.3-1954).

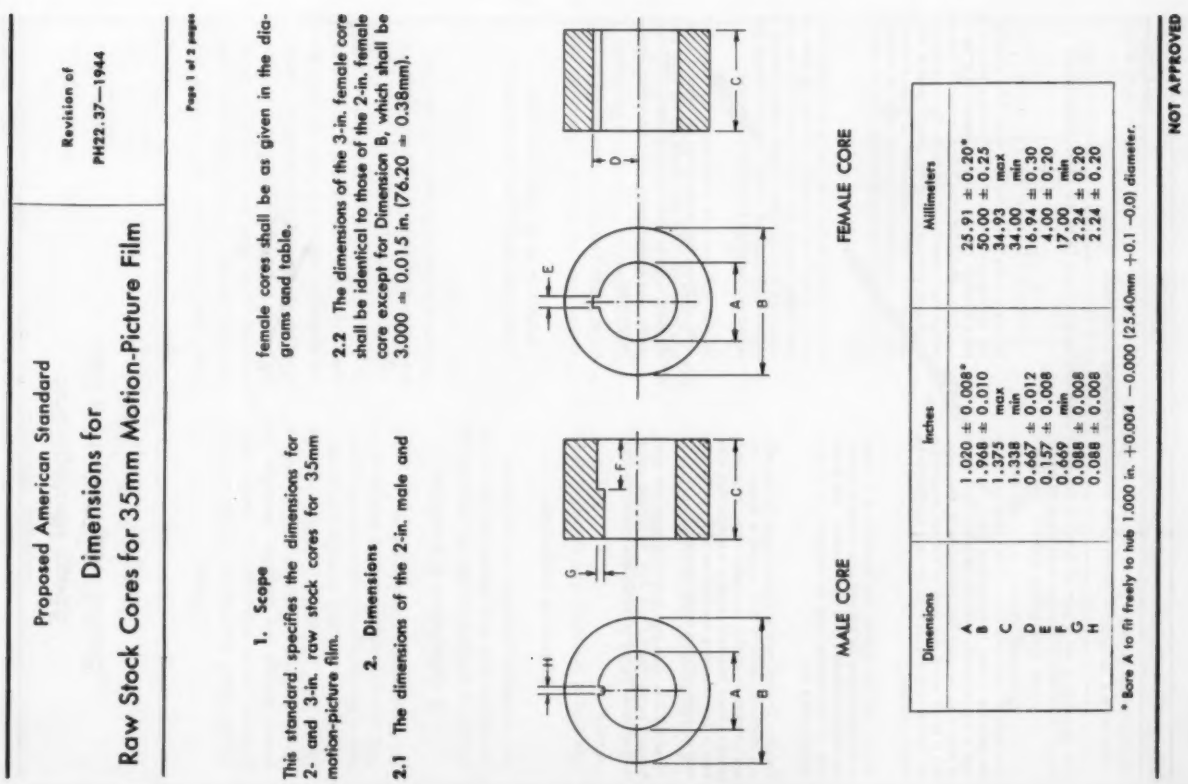
PH22.43-1961, 16mm 3000-Cycle Flutter Test Film, Photographic Type (Revision of PH22.43-1953).

PH22.51-1961, Intermodulation Tests for 16mm Variable-Density Photographic Sound Prints (Revision of Z22.51-1946)

PH22.56-1961, Nomenclature for Motion-Picture Film Used in Studios and Processing Laboratories, Sections 1–4, (Revision of Z22.56-1947)

All of the revised standards reflect extensive modifications from the proposals published for trial and comment in the May 1960 Journal.

A copy of the above American Standards is available from the American Standards Association, Incorporated, 10 East 40 Street, New York 16, at a nominal cost.—A.E.A.



Proposed American Standard

Dimensions for

Raw Stock Cores for 35mm Motion-Picture Film

Revision of PH22.37—1944

Page 1 of 2 pages

1. Scope

This standard specifies the dimensions for 2- and 3-in. raw stock cores for 35mm motion-picture film.

2. Dimensions

2.1 The dimensions of the 2-in. male and female cores shall be as given in the diagrams and table.

2.2 The dimensions of the 3-in. female core shall be identical to those of the 2-in. female core except for Dimension B, which shall be 3.000 ± 0.015 in. (76.20 ± 0.38mm).

MALE CORE

FEMALE CORE

Dimensions	Inches	Millimeters
A	1.020 ± 0.008*	25.91 ± 0.20*
B	1.968 ± 0.010	50.00 ± 0.25
C	1.375 max	34.93 max
	1.338 min	34.00 min
D	0.667 ± 0.012	16.94 ± 0.30
E	0.157 ± 0.008	4.00 ± 0.20
F	0.669 min	17.00 min
G	0.088 ± 0.008	2.24 ± 0.20
H	0.088 ± 0.008	2.24 ± 0.20

* Bore A to fit freely to hub 1.000 in. +0.004 −0.000 (25.40mm +0.1 −0.0) diameter.

NOT APPROVED

APPENDIX

(This Appendix is not a part of American Standard Dimensions for Raw Stock Cores for 35mm Motion-Picture Film, PH22.37, but is intended to facilitate its use.)

Two styles of nominally 2-in. (50mm) cores are in use for spooling 35mm motion-picture film. The male core is conventionally used for negative films, sound or picture, or for other films such as duplicating negative, any of which are used in camera magazines. The female core is conventionally used for films to be used on printers.

The key and the keyway are provided as a means of driving the core for take-up or a means of providing holdback tension on a feed spindle. The dimensions of the keyway shall be adequate to clear a square-ended key.

The 3-in. (76mm) core is recommended for use with raw stock rolls 2000 ft (610 meters) or longer. Experience has shown that the higher torque involved in handling these long rolls requires a female style core, since a key extending one-half the width of the core may not have sufficient tensile strength.

When the 2-in. male core is used to spool raw stock, it should be so oriented that when the outside end of the film leaves the roll at the top and toward the right, the key is in the side of the core toward the observer. The manufacturer may, at his discretion, provide a slot into which the film may be lapped in order to spool it snugly to the core. Such spooling is usually designated "wound on." When the film is spooled on a collapsible mandrel and the core is inserted after spooling, it is usually designated as "core inserted." This latter designation is not to be taken as referring to whether or not the end of the film is lapped into the core.

In the spooling of film to be used in high-speed cameras, it is the usual practice to snub the film onto the core without lapping the end in a slot so that the end will not be crimped. Such a crimp passing through a camera mechanism at several thousand frames per second may seriously damage the mechanism.

The maximum value for Dimension C is the minimum width of 35mm film as described by relevant American Standards. The core should not be wider than the film in order to avoid difficulty with tight-winders, widely used in the industry, which have fixed flanges for guiding.

Proposed American Standard

Magnetic Coating of 16mm Magnetic-Photographic Sound Record

PH22.127

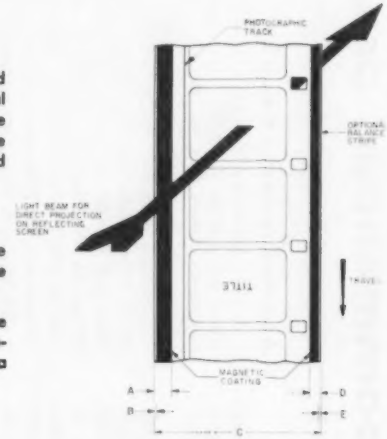
1. Scope

This standard specifies the dimensions and location of the magnetic coating material applied to 16mm prints, containing picture and photographic sound record, for the purpose of employing both a magnetic and the existing photographic sound record.

2. Dimensions

2.1 The dimensions and location of the magnetic coating shall be as specified in the diagram and table.

2.2 The magnetic coating shall be on the side of the film toward the lamp on a projector arranged for direct projection on a reflection type screen.



Dimensions	Inches	Millimeters
A	0.058 max 0.053 min	1.47 max 1.35 min
B	0.005 max	0.13 max
C	0.628 nom	16.0 nom
D	0.031 max 0.028 min	0.79 max 0.71 min
E	0.002 max	0.05 max

NOTES

1. This standard is not recommended for unilateral variable-area track.

2. The balance stripe is optional and may be a magnetic coating or another material of the same thickness.

3. A photographic sound record on this film will be partially overcoated by the magnetic stripe. However, experience shows that the photographic record can be reproduced acceptably if it has been recorded in accordance with American Standard Photographic Sound Record on 16mm Prints, PH22.41-1957.

4. When the following American Standard referred to in this document is superseded by a revision approved by the American Standards Association, Incorporated, the revision shall apply: American Standard Photographic Sound Record on 16mm Prints, PH22.41-1957.

American Standard

35mm Photographic Sound Motion-Picture Film, Usage in Projector

ASA
Reg. U.S. Pat. Off.
PH22.3-1961
Revision of
PH22.3-1954
*UDC 778.554.45

1. Scope

This standard specifies the manner in which a 35mm sound motion-picture release print passes through the projector, including the direction of travel, orientation of the picture image, rate of picture projection, and the length of the film path from the picture aperture to the photographic sound scanning point. This standard applies only to positive prints made from conventional negatives.

2. Orientation of Emulsion

Except for special processes, the emulsion side of the film shall face toward the light source in the projector, as shown in the diagram.

3. Rate of Projection

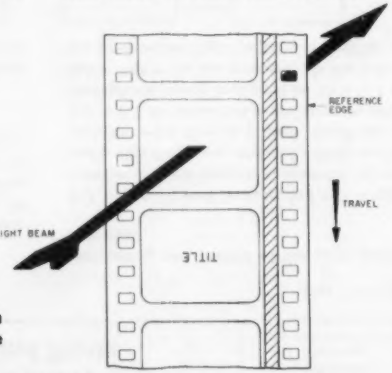
The rate of projection shall be 24 frames per second.

4. Relationship Between Photographic Sound and Picture

When the photographic sound record is reproduced, the distance from the center of the projector aperture to the photographic sound scanning point shall be adjusted to bring the picture and photographic sound into synchronism for the average observer. Usually this separation will be 20 frames. This provides synchronism for an observer at a distance of 50 ft from the speaker. The location and dimensions of the photographic sound record shall be as specified in American Standard Photographic Sound Record on 35mm Prints, PH22.40-1957.

5. Revision of American Standard Referred to in This Document

When the following American Standard referred to in this document is superseded by a revision approved by the American Standards Association, Incorporated, the revision shall apply: American Standard Photographic Sound Record on 35mm Prints, PH22.40-1957.



Drawing shows film as seen from the light source in the projector.

Approved May 19, 1961, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers
*Universal Decimal Classification

Copyright 1961 by the American Standards Association, Incorporated
10 East 40th Street, New York 16, N.Y.

Printed in U.S.A.
ASA%M761/60

American Standard

16mm 3000-Cycle Flutter Test Film, Photographic Type

ASA
Reg. U.S. Pat. Off.
PH22.43-1961
Revision of
PH22.43-1953
*UDC 778.554.45

1. Scope

This standard specifies a 3000-cycle sound test film for use in determining the amount of flutter in 16mm sound motion-picture projectors.

2. Test Film

2.1 *Recording.* The test film shall have either an originally recorded, direct-playback positive variable-area sound record or an originally recorded variable-density sound record developed as a toe record.† The recorded frequency shall be within ± 25 cycles of the nominal 3000-cycle frequency. The modulation of the recording shall be 80 ± 5 percent. The output level of the film shall be constant within ± 0.25 db. (This is equivalent to an amplitude tolerance of ± 0.0015 in. when recording variable-area sound records with a nominal amplitude of 0.055 in.) The recording shall be accomplished in a recorder so constructed as to keep the flutter content to the absolute minimum consistent with the state of the art. The total rms flutter content of the film shall be less than 0.07 percent upon shipment by the test manufacturer, as defined in American Standard Method of Determining Flutter Content of Sound Recorders and Reproducers, Z57.1-1954. The waveform distortion of the recording shall not exceed 5 percent.

2.2 *Film Stock.* The film stock shall be of safety type, cut and perforated in accordance with American Standard Dimensions for 16mm Film, Perforated One Edge, PH22.12-1953.

2.3 *Standard Length of Film.* The standard length of the flutter test film shall be 380 ft.

2.4 *Leader and Trailer.* Each test film shall be furnished with a suitable leader, title and trailer.

3. Revision of American Standards Referred to in This Document

When the following American Standards referred to in this document are superseded by a revision approved by the American Standards Association, Incorporated, the revision shall apply: American Standard Dimensions for 16mm Film, Perforated One Edge, PH22.12-1953; American Standard Method of Determining Flutter Content of Sound Recorders and Reproducers, Z57.1-1954.

Note: A test film in accordance with this standard is available from the Society of Motion Picture and Television Engineers.

†References

Donald Mackenzie, "Straight-line and toe records with the light valve," *Jour. SMPE*, 17: 172–202, Aug. 1931.

C. R. Keith and V. Pagliarulo, "Direct-positive variable density recording with the light valve," *Jour. SMPE*, 52: 690–698, June 1949.

Approved May 19, 1961, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers
*Universal Decimal Classification

Copyright 1961 by the American Standards Association, Incorporated
10 East 40th Street, New York 16, N.Y.

Printed in U.S.A.
ASA%M761/60

American Standard

Intermodulation Tests for 16mm Variable-Density Photographic Sound Prints

ASA
Reg. U.S. Pat. Off.
PH22.51-1961
Revision of
Z22.51-1946
UDC 778.5:771.531.531.2:620.1

1. Scope

This standard specifies the technique of measuring, by the intermodulation method, the signal distortion introduced during recording, processing, printing and reproduction of 16mm variable-density sound motion-picture prints.

2. Test Method

2.1 The test track shall consist of two sections, recorded in sequence at the same lamp-current setting and printed at the same printer light step.

2.2 Section 1 shall be recorded with a combination of a low frequency, nominally 60 cps, and a high frequency, nominally 2000 cps, the complex wave having a peak amplitude of 2.0 ± 0.5 db below full modulation, in which the high-frequency level shall be 12.0 ± 1 db below that of the low frequency. In the following the low and high frequencies shall be assumed to be 60 cps and 2000 cps, respectively. The test signals shall be not more than ± 3 percent from the nominal frequencies to be used. Neither frequency shall contain more than 5 percent harmonic distortion. A suitable length for this section is 6 ft, which provides about 10 sec in running time.

2.3 Section 2 shall be an unbiased, unmodulated track of sufficient length for density measurement.

2.4 The test tracks, as described in 2.2 and 2.3, shall be recorded and developed under standard conditions for the process being checked, and a series of prints of both sections 1 and 2 made at suitable printer lights to give a range of print densities above and below the expected optimum density. There shall be sufficient unspliced film ahead of the test track to permit stabilization of printer speed. The intermodulation distortion content of the recorded section of the test-track print shall then be measured using equipment as shown in Fig. 1. In making the measurements, the test-track print shall be run through the soundhead of the film-reproducing device in the proper manner according to the position of the soundtrack.

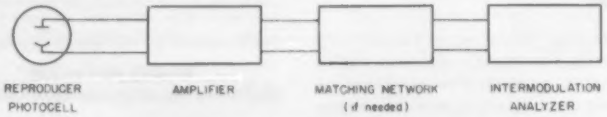


Fig. 1. Arrangement of Intermodulation Test Apparatus to Determine Distortion on Test Track

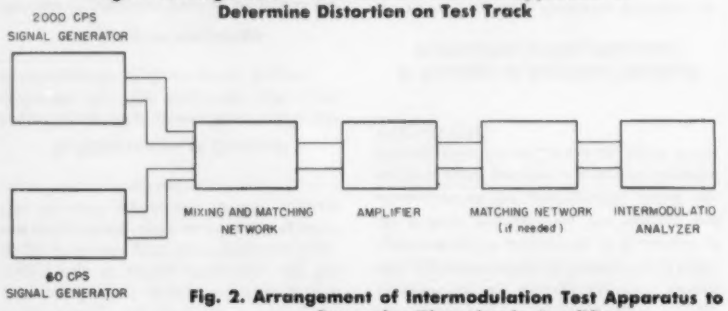


Fig. 2. Arrangement of Intermodulation Test Apparatus to Determine Distortion in Amplifier

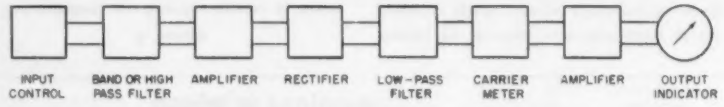


Fig. 3. Block Diagram of an Acceptable Intermodulation Analyzer

Approved May 19, 1961, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Copyright 1961 by the American Standards Association, Incorporated
10 East 40th Street, New York 16, N.Y.

Printed in U.S.A.
ASA%M761/30

2.5 In the recording and processing of the test tracks, as the print density is purposely varied to find an optimum, all other probable variables shall be maintained at one value for a printer light series.

2.6 To determine the optimum for other variables, additional test tracks shall be made, in each of which only one variable is changed while all others are invariant. For example: The negative gamma may be changed to a new value and a new series of prints made and measured. The minima for all tests, consistent with prevailing practices, represent the optima for all variables tested.

3. Test Equipment

3.1 *Amplifiers.* The recording and reproducing amplifiers shall not produce more than 2 percent intermodulation distortion when the intermodulation frequencies are introduced directly into the input, as shown in Fig. 2, at approximately the same level as that used when recording or measuring intermodulation distortion on a film.

3.2 *Intermodulation Analyzer.* A block diagram of an acceptable intermodulation analyzer is shown in Fig. 3.

APPENDIXES

(These Appendixes are not a part of American Standard Intermodulation Tests for 16mm Variable-Density Photographic Sound Prints, PH22.51-1961, but are included to facilitate its use.)

Appendix A

The intermodulation method is a means of measuring distortion which differs from the harmonic method in that the former employs a low frequency and a high frequency at one fourth the amplitude of the low frequency, the combination being simultaneously recorded on the sound negative. Any distortion in the overall process causes a change in high-frequency amplitude in portions of the low-frequency cycle. The ratio of the average variation in amplitude of the higher frequency in the reproduced wave to its original amplitude is called the intermodulation distortion. Intermodulation distortion test results are not directly proportional to harmonic distortion measurements.

Appendix B

Through measurements of intermodulation distortion at various print densities, it is possible to choose a print density which will give sound prints having minimum intermodulation distortion and hence optimum quality for the particular method of processing employed. For good results the intermodulation distortion minima should not exceed 10 percent.

Appendix C

In most cases the prints mentioned in 2.4 will be in the density range from 0.4 to 0.7.

Appendix D

The variables mentioned in 2.5 and 2.6 include the films (both sound negative and print), recorder lamp current, negative gamma, positive gamma, spectral-energy distribution of printer light and type of printer (contact or optical). Any type of modulation in the amplitude of the higher frequency at a lower frequency rate, such as may result from variations in the degree of contact between negative and print in a contact printer, will be also measured on an intermodulation analyzer.

Appendix E

A periodical test for spurious variations is recommended, whereby a third section of test track should be recorded as described for section 1 in paragraph 2.2, except that the low-frequency signal is omitted. Intermodulation distortion measured from this recording will be other than that caused by the nonlinearity of the negative exposure-print density characteristic.

Appendix F

Volume indicators such as the Standard Volume Indicator described in American Standard Volume Measurements of Electrical Speech and Program Waves, C16.5-1954, do not indicate true peak values for complex signals such as the combination of 60 cps and 2000 cps. The peak value of the complex signal will be 2.0 db ± 0.5 db below full modulation if the low-frequency signal alone is 4.0 db below full modulation.

Appendix G

Care should be taken that the reproducer photocell and coupling circuit to the reproducer amplifier do not introduce a significant amount of intermodulation distortion. The complete reproducing system should be checked at reasonable intervals to ensure acceptable test conditions.

Appendix H

The intermodulation analyzer should measure with frequency discrimination of less than ± 1 db an amplitude modulated signal for a sideband width within the frequency range of 2000 ± 400 cps. The intermodulation analyzer should have sufficient amplification to measure the high-frequency carrier at an input level of — 10 dbm, as for example, in the test described in Appendix E.

References

J. G. Frayne and R. R. Scoville, "Analysis and measurement of distortion in variable-density recording," *Jour. SMPE*, 32: 684, June 1939.

J. G. Frayne and Halley Wolfe, *Sound Recording*, John Wiley & Sons, New York, 1949 (Chapter 21).

C. J. LeBel, "An experimental study of distortion," *J. Audio Eng. Soc.*, 2: 215–218, Oct. 1954.

J. Ross Macdonald, "The calibration of amplitude modulation meters with a heterodyne signal," *Proc. I.R.E.*, 42: 1515–1518, Oct. 1954.

G. W. Reed and R. R. Scoville, "An improved intermodulation measuring system," *Jour. SMPE*, 50: 162, Feb. 1948.

W. J. Warren and W. R. Hewlett, "An analysis of the intermodulation method of distortion measurement," *Proc. I.R.E.*, 36: 457–466, Apr. 1948.

American Standard

Nomenclature for Motion-Picture Film Used in Studios and Processing Laboratories

(Sections 1-4)

ASA
Reg. U.S. Pat. Off.
PH22.56-1961
Revision of
222.56-1947
*UDC 778.5.001.4

1. General

1.1 *Motion-Picture Film.* Motion-picture film is a thin flexible ribbon of transparent plastic having perforations and bearing one or more sensitized layers capable of producing photographic images.

Note: The term "film" may be applied to unexposed film, to exposed but unprocessed film, and to exposed and processed film.

1.1.1 *Raw Stock.* Raw stock is film which has not been exposed or processed.

1.1.2 *Film Base.* Film base is the plastic material upon which a photographic emulsion is coated; namely, the support for the emulsion in photographic film.

Note: All film base manufactured in the United States for motion-picture use since 1952 has been safety base.

1.1.2.1 *Safety Base.* Safety base is the slow-burning film support used for motion-picture films which complies with American Standard Motion-Picture Safety Film, PH22.31-1958.

1.2 *Magnetic Film.* Magnetic film is a film base having film perforations along one or both edges and bearing a ferromagnetic coating, either completely across the film or in stripes, the coating capable of accepting and reproducing sound records.

Note: Unperforated materials usually are referred to as magnetic tape.

1.3 *Film Perforations.* Film perforations are the regularly and accurately spaced holes that are punched throughout the length of motion-picture film. These holes are engaged by the teeth of various sprockets and pins by which the film is transported and positioned as it travels through cameras, processing machines, projectors and other film-handling machinery.

1.3.1 *Perforation Pitch.* The perforation pitch is the distance from the bottom edge of one perforation to the bottom edge of the next perforation, measured along the length of the film.

Note: Perforations are being identified currently by two-letter designations such as BH (Bell & Howell), KS (Kodak Standard), DH (Dubray-Howell) or CS (CinemaScope). A numeral, such as 1866, designates the pitch in ten thousandths of an inch. A designation 1R, 2R or 4R, used with films having 16mm perforations, refers to the number of rows of perforations across the narrow dimension of the film.

1.3.2 *35mm Perforation, BH-1866.* The 35mm negative perforation has sharp corners, curved sides, a maximum width of 0.110 in. and a height of 0.073 in. (American Standard Dimensions for 35mm Motion-Picture Short-Pitch Negative Film, PH22.93-1953).

Note: This perforation is used for negative and some special-purpose 35mm films.

1.3.3 *35mm Perforation, KS-1870.* The 35mm positive perforation is rectangular in shape, with a width of 0.110 in., a height of 0.078 in. and a fillet in each corner with a radius of 0.020 in. (American Standard Dimensions for 35mm Motion-Picture Positive Raw Stock, PH22.36-1954).

Note: This perforation is used on most positive 35mm film.

1.3.4 *35mm Perforation, DH-1870.* This perforation is rectangular in shape, with a height of 0.073 in., a width of 0.110 in. and a fillet in each corner with a radius of 0.013 in. (American Standard Dimensions for 35mm Motion-Picture Film, Alternate Standards for Either Positive or Negative Raw Stock, PH22.1-1953).

Note: This perforation is used on 35mm color print film.

1.3.5 *35mm Perforation, CS-1870.* This perforation is rectangular in shape, with a height of 0.073 in., a width of 0.078 in. and a fillet in each corner with a radius of 0.013 in. (American Standard Dimensions for 35mm Motion-Picture Films, CS-1870, PH22.102-1956). The outer edge of this perforation is at a different distance from the edge of the film than the other 35mm film perforations listed above.

Note: This perforation is used mainly on color positive film.

Approved May 19, 1961, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Copyright 1961 by the American Standards Association, Incorporated
10 East 40th Street, New York 16, N.Y.

Printed in U.S.A.
ASA\$,M761/70

1.3.6 *16mm Perforation.* The 16mm perforation is rectangular in shape, with a height of 0.050 in., a width of 0.072 in. and a fillet in each corner with a radius of 0.010 in. It is used on the following films:

1.3.6.1 *35mm Motion-Picture Film Perforated 32mm, 2R-2994.* This is a 35mm film with 16mm perforations so arranged that if 1½ mm were slit from each edge of the film and the film were slit down the middle, two 16mm films would result, each having one row of perforations. The perforation pitch (0.2994 in.) is normally used for negative film and some special-purpose films (American Standard Dimensions for 35mm Motion-Picture Film, Perforated 32mm, 2R-2994, PH22.73-1958).

1.3.6.2 *35mm Motion-Picture Film Perforated 32mm, 2R-3000.* This is a 35mm film with 16mm perforations so arranged that when 1½ mm are slit from each edge of the film and the film is slit down the middle, two 16mm films result, each with one row of perforations. The perforation pitch specified is normally used for positive film and some special-purpose films.

1.3.6.3 *32mm Motion-Picture Film, 2R-3000.* This is a film 32mm in width which when slit down the middle results in two 16mm films each having one row of perforations (American Standard Dimensions for 32mm Motion-Picture Film, 2R-3000, PH22.71-1957). This perforation pitch is used mainly on positive film.

1.3.6.4 *32mm Motion-Picture Film, 4R-3000.* This is a film 32mm in width which when slit down the middle results in two 16mm films each having two rows of perforations (American Standard Dimensions for 32mm Motion-Picture Film, 4R-3000, PH22.72-1957). This perforation pitch is normally used on positive film.

1.3.6.5 *16mm Motion-Picture Film, 1R-2994.* This film is 16mm in width, perforated along one edge only (American Standard Dimensions for 16mm Motion-Picture Film, 1R-2994, PH22.109-1958). This perforation pitch is normally used on negative film.

1.3.6.6 *16mm Motion-Picture Film, 1R-3000.* This film is 16mm in width, perforated along one edge only (American Standard Dimensions for 16mm Film, Perforated One Edge, PH22.12-1953). This perforation pitch is normally used on positive film.

1.3.6.7 *16mm Motion-Picture Film, 2R-2994.* This film is 16mm in width, perforated along both edges (American Standard Dimensions for 16mm Motion-Picture Film, 2R-2994, PH22.110-1958). This perforation pitch is normally used on both black-and-white and color camera films.

1.3.6.8 *16mm Motion-Picture Film, 2R-3000.* This film is 16mm in width, perforated along both edges (American Standard Dimensions for 16mm Film, Perforated Two Edges, PH22.5-1953). This perforation pitch is normally used on positive film.

1.4 *Photographic Emulsions.* A photographic emulsion consists of dispersions of light-sensitive materials in a colloidal medium, usually gelatin, carried as a thin layer on film base.

Note: Photographic materials are usually designated as negative or positive types according to their light sensitivity (speed), or usage; negative emulsions, in general, being more sensitive than positive emulsions.

1.4.1 *Black-and-White Film.* Black-and-white film carries an emulsion in which, after processing, brightness values of a scene are reproduced only in tones of the gray scale.

1.4.2 *Color Film.* Color film carries one or more emulsions in which, after processing, brightness values of a scene are reproduced in terms of color scales.

1.4.3 *Reversal Film.* A reversal film is one which, after an exposure, is processed by a first development, a bleach and a redevelopment to produce a positive image. If exposure is made by printing from a negative, a negative image is produced by the reversal process.

1.5 *Image (Photographic).* An image is any photographically obtained likeness in a processed photosensitive material.

1.5.1 *Latent Image.* A latent image is the invisible image registered on a photographic emulsion due to the reaction produced in the emulsion by exposure to radiant energy.

Note: This image becomes visible after development.

1.5.2 *Picture Image.* A picture image is a photographically obtained likeness of any object on photographic material.

1.5.3 *Sound Image.* A sound image is a photographically obtained soundtrack or sound record.

1.5.4 *Negative Image.* A negative image is a photographic image in which the brightness scale is approximately inverted with respect to the brightness scale of the original subject. In color negatives the hue scale is usually, but not necessarily, complementary to the hue scale of the original subject and the brightness scale is inverted.

1.5.5 *Positive Image.* A positive image is a photographic replica in which the tones of the gray scale or color values of the originally photographed subject are represented in their natural order.

1.5.6 *Black-and-White Image.* A black-and-white image is an image produced on a black-and-white film.

1.5.7 *Color Image.* A color image is an image produced on a color film.

1.5.8 *Anamorphic Image.* An anamorphic image is an image which has been produced by an optical system having different horizontal and vertical magnifications.

Note: Equal horizontal and vertical magnification is assumed unless the term anamorphic is applied specifically.

1.6 *Aspect Ratio.* Aspect ratio is the ratio of width to height of a projected picture image.

Note: This is the more common usage, although the term is also applied to photographic images and to camera, printer and projector apertures.

1.7 *Synchronism.* Synchronism is the relation between the picture and sound with respect either to the physical location on the film or films or to the time at which corresponding picture and sound are seen and heard.

1.7.1 *Projection Synchronism.* Projection synchronism is the time relation between picture and corresponding sound in a projection print.

Note: The sound record on a projection print is, in most cases, in advance of the corresponding picture. The displacement is specified in picture frames in the following American Standards:

Soundtrack	Standard
A 35mm Photographic	PH22.40-1957
B 16mm Photographic	PH22.41-1957
C 35mm Magnetic*	PH22.103-1957
D 16mm Magnetic	PH22.112-1958
E 8mm Magnetic	†

1.7.2 *Editorial Synchronism.* Editorial synchronism is the relationship between the picture and sound film during the editorial process.

Note: During the editorial process, the soundtrack and corresponding picture, whether on the same or separate films, are kept in alignment and not offset as for projection. Many composite release negatives are supplied in editorial synchronism.

1.7.3 *Camera Synchronism.* Camera synchronism is the relation between picture and soundtrack in a composite camera original.

Note: Camera synchronism is generally not the same as editorial synchronism. In 16mm single systems the two are normally in projection synchronism but this is not the case for most 35mm single systems (i.e., where picture and sound are recorded on the same film).

1.8 *Exposure.* Exposure is the process of subjecting a photographic film to suitable intensity of radiant energy for a given time in such manner that it may produce a latent image on an emulsion.

Note: Exposure = intensity × time.

1.9 *Processing.* Processing is the generic term applied to the total operation necessary to produce a permanent visible image on exposed film.

1.9.1 *Development.* Development is that part of processing which makes visible the latent image of an exposed photographic emulsion.

1.9.2 *Fixing (Fixation).* Fixing (fixation) is that part of processing which removes the residual sensitive silver salts from a developed film to render the developed image permanent.

Note: During the process of fixation, films are customarily treated to preserve and harden the developed image. Adequate washing or neutralizing treatment is necessary following fixation for image permanence.

1.9.3 *Bleaching.* Bleaching is that part of processing which converts a developed silver image into a silver salt.

1.10 *Printing.* Printing is the operation of exposing raw stock by using the processed image of another film as the light modulator.

1.10.1 *Contact Printing.* Contact printing is that method of printing in which the raw stock is held in intimate contact with the film bearing the image to be copied.

1.10.1.1 *Step Contact Printing.* Step contact printing is that method of contact printing in which the film being copied and the raw stock are advanced intermittently frame-by-

*In this case, the sound is behind the corresponding picture.

†A standard is now under consideration by the SMPTE Sound Engineering Committee.

frame, being exposed to the printer light only when stationary.

1.10.1.2 *Continuous Contact Printing.* Continuous contact printing is that method of contact printing by which the light modulating film and the raw stock move at the same constant speed past the printing aperture.

1.10.2 *Projection Printing (Optical Printing).* Projection printing (optical printing) is printing by projecting the image to be copied through an optical system onto the raw stock.

Note: The printed image with respect to the projected image may be identical, an enlargement or a reduction or anamorphic image; or additional anamorphosis may be added or removed.

1.10.3 *A and B Printing.* A and B printing is a method of making composite images, such as fades, dissolves or effects, in a release printer without requiring a duplicating process.

Note: The name comes from the fact that the films are edited into two separate rolls called A and B rolls. The sequences of pictures originally in one roll are in synchronization with opaque leader in the other roll. When these two are printed in a separate operation onto a single roll of raw stock, an opportunity is afforded for the introduction of effects and for eliminating visible splices on the screen.

1.11 *Projection.* Projection is the presentation of an enlarged image of the film on a screen for visual review. In addition the sound may be reproduced for aural review.

1.12 *Production.* Production is the general term used to describe the processes involved in making all the original material that is the basis for the finished motion picture.

1.13 *Editorial Process.* Editorial process is the term used to describe the combining, cutting, editing and other preparation of material obtained from the original material to make the finished motion picture.

1.14 *Re-recording.* Re-recording is the electrical process of transferring sound records from one or more films, magnetic tapes or discs to other films, tapes or discs.

Note: Re-recording may be used to combine different sound records into a single record to adjust the frequency-response characteristic or to adjust the relative levels between different scenes and sequences.

1.15 *Release.* Release is a generic term used to designate films used for or intended for general distribution and exhibition.

1.15.1 *Release Negative.* A release negative is a complete negative prepared specifically for printing release prints.

Note: A release negative may consist of separate picture and sound negatives and may be in either projection or editorial synchronism, depending upon the film-processing technique to be employed in making release prints.

1.15.2 *Release Print.* A release print is a print made for general distribution and exhibition. It may be on films of 8mm, 16mm, 35mm or 70mm width. Some release prints are composed of two or more 35mm-width films which are projected simultaneously in lateral alignment.

2. Picture Negative Film, Black-and-White and Color

2.1 *Picture Negative.* A picture negative is any processed film that possesses a negative picture image of the subject or film image to which it was exposed. This term is sometimes erroneously used to refer to the raw film before processing, either with or without exposure.

2.1.1 *Original Picture Negative.* The original picture negative is the negative film that was exposed in a camera and processed to produce a negative image of the original subject.

2.1.2 *Background Plate Negative.* A background plate negative is a picture negative which is used for printing background plates.

2.1.3 *Picture Library Negative.* A picture library negative is a picture negative that is usually held in a film library for use in reproducing scenes which would otherwise have to be made as original material for each production.

2.1.4 *Title Negative.* A title negative is a negative that is exposed to a title card or to both a title card and background.

2.1.5 *Picture Duplicate Negative.* A picture duplicate ("dupe") negative is a picture negative made from black-and-white, color or separation master positive films.

Note: It may be used for making additional prints or it may be cut and edited to form a part of the picture release negative.

2.1.5.1 *Internegative.* An internegative film is a negative derived directly from a color reversal original film.

Note: All other color duplicating negatives derived from other than reversal film will be known as color duplicate negatives regardless of the generation.

2.1.6 *Picture-Release Negative.* A picture-release negative is a cut and edited picture

negative used for printing the picture portion of release prints.

Note: It may consist of intercut original picture negatives, picture dupe negatives, etc., depending upon the choice of available material or the intended use of the release print.

2.1.7 *Foreign Picture-Release Negative.* A foreign picture-release negative is a picture-release negative prepared specifically for printing foreign-version release prints.

Note: It is almost invariably a duplicate negative.

2.1.8 *16mm Picture Release Negative.* A 16mm picture release negative is a picture release negative on 16mm film prepared specifically for printing 16mm release prints.

3. Picture Positive Film, Black-and-White and Color

3.1 *Picture Print.* A picture print is a processed film that possesses a positive picture image of the subject or film image to which it was exposed.

3.1.1 *Picture Daily Print.* A picture daily print is the first picture print made from the original picture negative for use in checking photographic quality, camera technique, actions, etc.

3.1.2 *Picture Work Print.* A picture work print is a positive print which usually consists of intercut picture daily prints, picture library prints, prints of dissolves, montages, titles, etc., and has synchronism constantly maintained with the corresponding sound work print.

3.1.3 *Picture Library Print.* A picture library print is a picture print made from a picture library negative.

3.1.4 *Background Plate (Background Print Film).* A background plate (background print film) is a picture print made specifically for use in projection background or similar process work, and is a print of a background plate negative.

3.1.5 *Picture Master Positive.* A picture master positive is a print usually made on a special film, for the purpose of producing picture duplicate negatives.

3.1.5.1 *35mm Separation Positive.* A 35mm separation positive is a black-and-white film with a positive image of the red, green or blue image component of a color negative. It is usually made by printing through suitable filters from a color negative onto a panchromatic black-and-white film.

3.1.5.2 *35mm Protection Master Positive.* A 35mm protection master positive film is a positive film made from the final cut and edited black-and-white or color release negative. In case of damage to the release negative, a duplicate negative could be made from this protection master positive. In the case of color, this protection master positive may be a set of three black-and-white separation master positives or a color master positive.

3.1.5.3 *35mm Panchromatic Master Positive.* A 35mm panchromatic master positive is a black-and-white print made on a panchromatic film from a color negative for the purpose of making a black-and-white duplicate negative.

3.2 *Composite Print.* A composite print is a positive film having both picture and corresponding sound on the same film, which may be in editorial or projection synchronism.

3.2.1 *Composite Daily Print.* A composite daily print is made from an original composite negative or original sound and picture negatives, and is used for checking photography, sound quality, action, etc. It is in projection synchronism.

3.2.2 *First Trial Composite Print.* The first trial composite is the first composite print made from the picture and sound-release negatives for the purpose of checking and correcting picture and sound quality, negative cutting and assembly, etc. It is in projection synchronism.

3.2.3 *Second, Third, Etc., Trial Composite Print.* The second, third, etc., trial composite print is similar to the first trial composite print, but has successive corrections incorporated as a result of viewing the previous trial composite prints.

3.2.4 *Final Trial Composite.* A final trial composite is a composite print, approved for release, in which all corrections found necessary in previous trial composite prints have been incorporated.

Note: The final trial composite may be any one of the various trial composite prints, depending upon the type and extent of corrections required.

3.2.5 *Composite Master Positive.* A composite master positive is a composite print usually made for the purpose of producing composite or picture and sound duplicate negatives which would be used for printing release prints.

Note: It is usually made on duplicating positive film and may be in either editorial or projection synchronism.

3.2.6 *Foreign-Version-Release Print.* A foreign-version-release print is a composite print in projection synchronism with dialogue made specifically for the particular language involved.

Note: Sometimes superimposed titles in a different language are used on the print. A superimposed title consists of printed words (usually transparent) overlaying the picture image.

3.2.7 *Foreign-Version Trial Composite Prints.* Foreign-version trial composite prints are similar to trial composite prints made during release, except that they are made for checking the release of the particular language version involved.

4. Reversal Film, Black-and-White and Color

4.1 *Reversal Original.* A reversal original is the film that is originally exposed in a camera or recorder and is processed by reversal to produce a positive image.

Note: This positive image obtained by the reversal process is not the same as a print from a negative inasmuch as right and left are transposed; when viewed by projection on an opaque screen, the emulsion side of the print from a negative must face the light source and the emulsion side of a reversal original must face the lens in order for the screen image to have the same lateral orientation as the original scene.

4.1.1 *Composite Reversal Original.* A composite reversal original is a reversal original which has both picture and corresponding sound on the same film.

4.2 *Reversal Print.* A reversal print is a reversal-type film that has been exposed to a positive film image, usually a reversal original film, and processed by the reversal process.

4.2.1 *Reversal Master Print, 16mm.* A reversal master print is a 16mm reversal print made specifically for use in producing other prints.

Note: It is sometimes referred to as a first generation duplicate, prints from it then being referred to as second generation duplicates.

4.2.2 *Reduction Reversal Print, 16mm.* A reduction reversal print is a reversal print made on 16mm reversal film from a 35mm positive by reduction printing and development by the reversal process.

Revision of American Standards Referred to in This Document

When the following American Standards referred to in this document are superseded by a revision approved by the American Standards Association, Incorporated, the revision shall apply:

PH22.1-1953, Dimensions for 35mm Motion-Picture Film, Alternate Standards for Either Positive or Negative Raw Stock.
PH22.5-1953, Dimensions for 16mm Film, Perforated Two Edges.
PH22.12-1953, Dimensions for 16mm Film, Perforated One Edge.
PH22.31-1958, Motion-Picture Safety Film.
PH22.36-1954, Dimensions for 35mm Motion-Picture Positive Raw Stock.
PH22.40-1957, Photographic Sound Record on 35mm Prints.
PH22.41-1957, Photographic Sound Record on 16mm Prints.
PH22.71-1957, Dimensions for 32mm Motion-Picture Film, 2R-3000.
PH22.72-1957, Dimensions for 32mm Motion-Picture Film, 4R-3000.
PH22.73-1958, Dimensions for 35mm Motion-Picture Film, Perforated 32mm, 2R-2994.
PH22.93-1953, Dimensions for 35mm Motion-Picture Short-Pitch Negative Film.
PH22.102-1956, Dimensions for 35mm Motion-Picture Film, CS-1870.
PH22.103-1957, 35mm Anamorphic Prints with Magnetic Sound Records, Usage in Projector.
PH22.109-1958, Dimensions for 16mm Motion-Picture Film, 1R-2994.
PH22.110-1958, Dimensions for 16mm Motion-Picture Film, 2R-2994.
PH22.112-1958, Picture-Sound Separation in 16mm Magnetic Sound Projectors.

Index

Boldface numbers refer to paragraphs.

Aspect ratio . . . 1.6
Background plate . . . 3.1.4
Base
  film . . . 1.1.2
    safety . . . 1.1.2.1
Bleaching . . . 1.9.3
Development . . . 1.9.1
Editorial process . . . 1.13
Editorial synchronism . . . 1.7.2
Emulsions, photographic . . . 1.4
Exposure . . . 1.8
Film
  background print . . . 3.1.4
  base . . . 1.1.2
  black-and-white . . . 1.4.1
  color . . . 1.4.2
  composite reversal original . . . 4.1.1
  magnetic . . . 1.2
  motion-picture . . . 1.1
  protection master positive, 35mm . . . 3.1.5.2
  raw stock . . . 1.1.1
  reversal . . . 1.4.3
  reversal original . . . 4.1
  separation positive, 35mm . . . 3.1.5.1
Film perforations . . . 1.3
  pitch . . . 1.3.1
  16mm . . . 1.3.6
    35mm perforated 32mm, 2R-2994 . . . 1.3.6.1
    35mm perforated 32mm, 2R-3000 . . . 1.3.6.2
    32mm, 2R-3000 . . . 1.3.6.3
    32mm, 4R-3000 . . . 1.3.6.4
    16mm, 1R-2994 . . . 1.3.6.5
    16mm, 1R-3000 . . . 1.3.6.6
    16mm, 2R-2994 . . . 1.3.6.7
    16mm, 2R-3000 . . . 1.3.6.8
  35mm negative, BH-1866 . . . 1.3.2
  35mm positive, KS-1870 . . . 1.3.3
  35mm, DH-1870 . . . 1.3.4
  35mm, CS-1870 . . . 1.3.5
Fixing (fixation) . . . 1.9.2
Image (photographic) . . . 1.5
  anamorphic . . . 1.5.8
  black-and-white . . . 1.5.6
  color . . . 1.5.7
  latent . . . 1.5.1
  negative . . . 1.5.4
  picture . . . 1.5.2
  positive . . . 1.5.5
  sound . . . 1.5.3
Internegative . . . 2.1.5.1
Negative
  background plate . . . 2.1.2
  foreign picture-release . . . 2.1.7
  original picture . . . 2.1.1
  picture . . . 2.1
  picture duplicate . . . 2.1.5
  picture library . . . 2.1.3
  picture-release . . . 2.1.6
  picture-release, 16mm . . . 2.1.8
  release . . . 1.15.1
  title . . . 2.1.4
Perforation, see also Film perforations
  pitch . . . 1.3.1
Print
  composite . . . 3.2
  composite daily . . . 3.2.1
  composite master positive . . . 3.2.5
  final trial composite . . . 3.2.4
  first trial composite . . . 3.2.2
  foreign-version release . . . 3.2.6
  foreign-version trial composite . . . 3.2.7
  panchromatic master positive, 35mm . . . 3.1.5.3
  picture . . . 3.1
  picture daily . . . 3.1.1
  picture library . . . 3.1.3
  picture master positive . . . 3.1.5
  picture work . . . 3.1.2
  reduction reversal, 16mm . . . 4.2.2
  release . . . 1.15.2
  reversal . . . 4.2
  reversal master, 16mm . . . 4.2.1
  trial composite, second, third, etc. . . . 3.2.3
Printing . . . 1.10
  A and B . . . 1.10.3
  contact . . . 1.10.1
    continuous . . . 1.10.1.2
    step . . . 1.10.1.1
  projection (optical) . . . 1.10.2
Processing . . . 1.9
Production . . . 1.12
Projection . . . 1.11
  printing . . . 1.10.2
  synchronism . . . 1.7.1
Raw stock . . . 1.1.1
Release . . . 1.15
  negative . . . 1.15.1
  print . . . 1.15.2
Re-recording . . . 1.14
Safety base . . . 1.1.2.1
Synchronism . . . 1.7
  camera . . . 1.7.3
  editorial . . . 1.7.2
  projection . . . 1.7.1

SMPTE Recommended Practice RP 8*

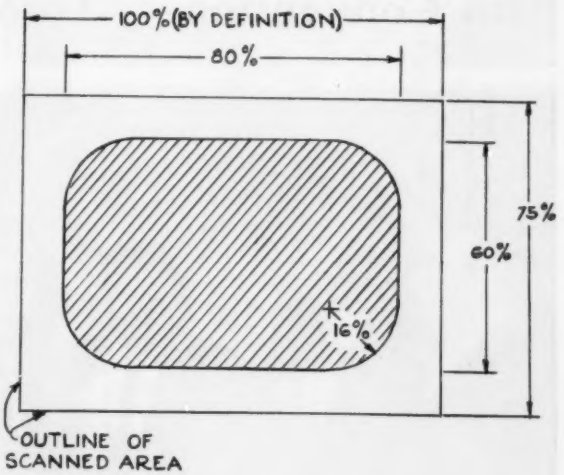
This Recommended Practice originated in the Television Committee. The proposal, approved by the initiating committee and the Standards Committee, was published for trial and comment in the January 1961 Journal. The recommendation received final approval by the Society's Board of Governors on May 7, 1961.

Safe Title Area for TV Transmission

1. *Scope*
   - 1.1 Existing standards define the camera aperture, projector aperture and scanned area for each of the media commonly used as sources of photographic material for television transmission.
   - 1.2 This Recommended Practice suggests restrictions on the location of essential information (e.g., titles, station call letters and sponsor identification) with the intent of insuring visibility of that information on the great majority of home receivers as typically operated.

2. *Recommended Practice*
   - 2.1 For any form of motion picture or slide material, titles and other essential information should be kept within the shaded portion of the drawing.
   - 2.2 The dimensions of the drawing are stated in terms of percent of the nominal scanned area transmitted by the television system. 100% is, by definition, equal to the width of the scanned area and 75% is then the height of the scanned area.
   - 2.3 For operating convenience, it is suggested the outline of the shaded area be indicated in all camera viewfinders.

3. *Related Concepts of Image Area*
   - 3.1 The safe title area should not be confused with either the safe action area or the scanned area.
   - 3.2 As a matter of terminology, it should be noted that this SMPTE Recommended Practice defines an area almost equal to the "safe title" area defined by the Motion Picture Research Council. The Research Council further defined a "safe action" area which is larger than the "safe title" area or the area defined by this SMPTE Recommended Practice. The "safe action" area is that area outlined on the viewfinder of action cameras operating in accordance with Research Council Practices.



   - 3.3 Scanned Area is defined quantitatively by the American Standards in Section 4.

4. *Reference Standards*
   - 4.1 The dimensions of the various scanned areas will be found in the following American Standards:
     Television Picture Area — 16mm Motion-Picture Film, PH22.96-1954
     Television Picture Area — 35mm Motion-Picture Film, PH22.95-1954
     Slides and Opaques for Television Film Camera Chains, PH22.94-1954

* A copy of this Recommended Practice may be obtained without charge upon request directed to Alex E. Alden, Staff Engineer, at SMPTE headquarters.

90th SMPTE Convention, Lake Placid Club, New York

Detailed announcements in the May and June *Journals* may be referred to for the topics and Topic Chairmen for the Lake Placid Convention, October 1–6. Author forms and abstracts are due by July 17 and should be now in the mail or already in the hands of the Topic Chairmen or Program Chairman. Anyone still intending to contribute should wire immediately to the Program Chairman, C. Loren Graham, Kodak Park, Bldg. 65, Rochester 15, N.Y.

The Program Chairman reports that plans are coming along nicely for the presentation of several new and very interesting concepts. In keeping with the theme of the convention, papers are being planned on photography and transmission of images from satellites, on lunar mapping and on telescopic photography from stratosphere balloons. The impact of new concepts of education has brought about a systems analysis of methods of presentation which will be reported in a series of papers. This study has brought changes in the basic approach to projection techniques, for example, which will stimulate much interest and thinking on the part of all who are concerned with the presentation of ideas by means of images, in business and industry as well as in education.

The rapidly developing business in 8mm professional film, which was explored at the Toronto Convention, will be brought up to date. Among the topics to be discussed will be studies of film dimension requirements and of the picture quality resulting from various reproduction techniques.

A very lively panel discussion of the engineering features of several systems of subscription TV is expected.

news and reports

89th Convention — Toronto, Canada

Some of the top echelon at the Convention. Left to right: Reid H. Ray, Executive Vice-President; Gerald G. Graham, Local Arrangements Chairman; Harry Teitelbaum, Convention Vice-President; John W. Servies, President; Norwood L. Simmons, Past President.

A GREAT MANY years passed between the time that the Society first ventured beyond the borders of the United States to hold a convention until May 7th of this year when the 89th Convention opened at the King Edward Sheraton Hotel in Toronto, Canada, to discuss International Achievements in Motion Pictures and Television. The success of this meeting belied the fact, however, and indicated rather that the SMPTE was most welcome and at home in Canada.

Perhaps more than any other convention in recent years, the success of the 89th was dependent upon the precise arrangements of the local committees. This group, operating under the general supervision of Convention Vice-Presidents Reid H. Ray and Harry Teitelbaum, was made up of hard working individuals whose contribution to the success of the meeting extended over almost two years of careful planning. Originally constituted in 1959 as the Toronto Convention Planning Committee, with Gerald G. Graham as chairman, these Canadian Section members held regular meetings, circulated detailed progress reports, and devoted hours and hours of time and effort to preparing the unaccustomed details of an SMPTE Convention in Canada.

The Papers Program was well organized in advance under Editorial Vice-President Glenn E. Matthews, with Rodger J. Ross of Canadian Broadcasting Corp. as Chairman of this Papers Program Committee activity described later.

Local Arrangements Chairman Gerald G. Graham, who changed his hat from Chairman of the Toronto Convention Planning Committee to become Local Arrangements Chairman, is due a tremendous amount of thanks for his great contribution in all phases of the convention arrangements. His on-the-spot Vice-Chairman, Roger Beaudry of Toronto, served with exceptional vigor as the liaison between the committees and Mr. Graham and Mr. Teitelbaum. Ralph C. Ellis of Fremantle of Canada Ltd. was responsible for the selection of the many interesting motion-picture short subjects shown during the week.

Registration, always one of the big convention jobs, was especially busy and, fortunately, especially well organized and supervised by the Chairman, Donald W. Dixon, Canadian Kodak Sales Ltd. There were no precedents to rely on; few really expected that a convention in Toronto would attract more registrants than a convention in New York, or the 5th Congress in Washington. But this is what turned out to be the case. Beginning with four times as many people registering on Sunday as had been expected, heavy business continued at the Registration Desk all week — with a total of 928 registered, including 64 ladies. Under Don Dixon's capable management the whole operation ran smoothly and efficiently.

Lou T. Wise of Avro Aircraft Ltd. was the expert manager of hotel arrangements. The Ladies Program was in the capable hands of Chairman Frank L. Tate and Cohostesses Mrs. S. W. Caldwell and Mrs. F. L. Tate.

A. D. Turnbull and W. L. Walterhouse of General Sound and Theatre Equipment Ltd. were in charge of public address, recording and projection, an exacting task which was managed admirably, with the assistance of Joseph Grimaldi of Pathe-DeLuxe Labs, W. D. Devitt of Odeon Theatres of Canada, A. L. Greer of Twentieth Century Theatres and Kenneth Reason of General Theatres. The sound recording was carefully done by Hugh P. Mackin under Frank Knudsen of Professional Sound/-Picture Service.

Reginald S. "Tex" Rekert was special assignments chief and, as Mr. Teitelbaum remarked, "official worrier" in commending his terrific job. The delightful banquet was arranged by Arthur Chetwynd with professional skill. Spencer W. Caldwell engineered the highly successful Get-To-

Guest speaker John J. Fitzgibbons with Spence W. Caldwell, Chairman of the Luncheon Committee.

Overseas attendants at the Get-Together Luncheon: left to right: Dr. M. Jahoda, Ing. Jiri Struska, of the Czechoslovak State Film Corp.; Crista Singer of the Canadian Broadcasting Corp.; Leon Shelly of Leon Shelly & Co. Ltd., Toronto; Fred Orain, President, Commission Supérieure Technique du Cinéma, Paris; U. Karatsouba, Mark Krivocheev and Yuri Kroupin, of the Ministry of Communications, Moscow; and Frantisek Pilat of the Czechoslovak State Film Corp.

Another international table at the Luncheon; left to right: Percy Corry, Strand Electric Ltd., England; Miss Clark, Strand Electric Ltd., Toronto; Rollo G. Williams, Century Lighting, Inc., New York; Viktor Komar, Ministry of Culture, USSR; M. Z. Vyssotsky, Union of Cinematographers of the USSR; David W. Ridgway, CHEM Study, Harvey Mudd College, Calif.; unidentified guest; and F. P. Bentham, Strand Electric Ltd., England.

gether Luncheon. James B. Bach and Donald L. Clayton of Cinesound Ltd. audited the extensive registration, membership and publication sales.

Arthur C. Benson and Frank Young worked long and hard on the successful publicity campaign. Hospitality Chairman Mrs. A. L. Clark, Alex L. Clark Ltd., was assisted by Mrs. G. W. Farrow, Mrs. E. Patter and Miss J. Allen in that successful activity. The important job of meeting, escorting and generally looking after the visitors from overseas was most ably carried out by Tom Johnson of the National Film Board.

Membership Chairman John Alex Buist and his assistants, Bernard McAllister and Norman J. Valin, all of Minnesota Mining & Mfg. Co., set a record for obtaining new members during a convention. Ronald E. Ringler of DuPont Co. of Canada, who was responsible for transportation, was properly complimented for having met all requests with prompt service. Administrative Assistants Norman R. Olding, Elton W. Hamilton, Albert H. Simmons, Rudolph R. Epstein and Michael Stechly did a wonderful job of aiding wherever they were needed.

Papers Program

Under the guidance of the tireless Rodger J. Ross, the papers program expanded into a very large and diversified series of interesting sessions. As on other occasions, the participation of Editorial Vice-President Glenn E. Matthews was a helpful factor in the preparation of the program. Useful assistance was also given by Robert C. Rheineck, General Chairman of the Papers Committee and the successor of Bernard D. Plakun who was Chairman during the earlier phases of the program's development. Program Topic Chairmen were: Cinematography, Ivor B. M. Lomas; Films and Television in Education, Rudolph R. Epstein; Film Projection Equipment and Practices, Eric C. Johnson; Image Forming Systems, Allan L. Sorem; Instrumentation and High-Speed Photography, Morton Sultanoff; Laboratory Practices, Harold Jones; New Developments in 8mm, John Flory; Sound Recording and Reproduction, Kenneth MacKenzie; Standards and Standardization, Charles E. Anderson; Television Equipment, Richard E. Putman; Television Film, John G. Stott; Television Recording, Helmut Berger; and Television Studio Practices and Station Operation, Harold Wright.

From the quantity and high quality of papers on the program it is obvious that all of these men contributed a tremendous amount of effort to their tasks.

Record Sunday

Sunday, May 7th will no doubt go on record as being one of the most active Sundays in convention-week history. Some 350 persons registered between the hours of noon and 6:00 P.M. While the registration desk was being kept busy by arriving conventioneers, the SMPTE Governors were meeting in their regular session under the Chairmanship of President John W. Servies. Later in the day a near crisis developed when 350 persons showed up for the buffet dinner that had been planned for 75. Hotel officials met the emergency in haste and everyone enjoyed an excellent meal. Following the buffet, which was a new feature of Society Conventions, a showing of the new release film, *Pure Hell at St. Trinians*, was attended by most delegates. The film, distributed by 20th Century-Fox of Canada, was screened through the cour-

Norwood L. Simmons, left, and John W. Servies, right, talk with the guest speaker, John J. Fitzgibbons, before the Get-Together Luncheon.

Program Chairman Rodger J. Ross and Garland C. Misener, Sections Vice-President.

More visitors from abroad: Peter P. Rigby, Robert Rigby Ltd., London, and Harold P. Bastie, Ernest F. Moy Ltd., London.

tesy of Rank Film Distributors of Canada Ltd.

Big Opening Day

Monday morning, the already rapid pace of the convention increased greatly. The registration desk reported brisk business during the first few hours. As quickly as they registered most delegates rushed off to the nearby Tivoli Theatre where the first technical session of the convention was opened by Editorial Vice-President Glenn E. Matthews. An animated film welcome was presented by Norman McLaren of the National Film Board of Canada. The session was presided over by Kenneth M. Mason as chairman with Robert C. Crone as Vice-Chairman. Decidedly international in flavor, with representatives from the United States, Canada, Czechoslovakia and Russia participating, this session dealt with psychological aspects of motion-picture montage; effect techniques as aids to low budget production; motion-picture techniques and equipments in Czechoslovakia; international standardization of 70mm films; simulated night photography using color reversal films; and the super Technirama 70 Process. A very interesting 70mm film demonstration closed the morning session. The Society is grateful to the management of the Tivoli Theatre for making their facilities available for this session.

Overseas Participants

The volume of international attendance at this convention was matched only by that of the 5th International Congress on High-Speed Photography. Representatives from England, France, Belgium, Italy, Germany, South Africa, Japan, Czechoslovakia and the USSR participated in the meeting in addition to delegates from Canada and the United States.

Get-Together Luncheon

Prior to the luncheon, President John W. Servies entertained head table guests and members of the press at a reception in honor of the Luncheon Speaker John J. Fitzgibbons, Sr., President of Famous Players Corp.

Later, President Servies welcomed 368 delegates to the traditional Get-Together Luncheon and introduced the Prime Minister of Canada, John Diefenbaker, whose message of welcome was brought videotaped to the Convention through the facilities of the Taylor Video Corp. of Canada.

"On behalf of all Canadians," the Prime Minister said, "I want to extend a warm welcome to the members of the Society of Motion Picture and Television Engineers...

"I would like to convey a special greeting to the visitors from Britain, the United States, France, Germany, Japan, USSR, Italy, Belgium and Czechoslovakia.

"The theme of the Convention, 'International Achievements in Motion Pictures and Television,' is most timely, because today we stand on the threshold of international television.

"The potentialities of this new horizon appeal to me personally because of its implication for the recognition of equality among all mankind, regardless of race or creed, for which I have always contended. I am convinced that international television can be a major instrument with which this philosophy can be implemented and world understanding achieved.

"Indeed, it is only through world understanding, on a people-to-people basis, that lasting peace can be brought about.

"To facilitate the easy flow of programs from country to country, I hope that all of you will work towards technical integration and standardization in international television.

"My government is fully aware of the great potential your industries hold for Canada; we for our part will co-operate in every way with our friends in other countries.

"I hope that you all enjoy your stay in our country, and that your meetings during the week will bring us closer to world understanding through international television."

Leon Shelly of Leon Shelly and Company arranged for the Taylor Corp. to record Mr. Diefenbaker's message in the Prime Minister's Office in Ottawa.

President Servies Speaks

"SMPTE has been since the days of its infancy, an organization of international scope and international membership." President Servies told the luncheon audience. "As the years have passed, this internationalism has intensified, until now we find ourselves on the record as having sponsored two major international events within twelve months. First, the Fifth International Congress on High-Speed Photography, ... now, this present 89th Convention of the Society, devoted to International Achievements in Motion Pictures and Television.

"Because they represent the very heart of the Society's aims and purposes," he said, "namely, the world-wide advancement of motion picture and television technology, these two international events are milestones in the Society's history. . . .

". . . .The exchange of knowledge and ideas made possible by the international forums provided by the Society's conventions . . . will serve to strengthen the communicative powers of mankind.

"The Society has been diverse in its interests and in its endeavors through the years, as has befitted the industry which it serves. It has modernized its approach and its attitudes to keep pace with an ever-changing, ever-expanding industry. We have specialized, where specialty was the requirement, and, we have generalized, when the call has been for generalities.

"The divergent aspects of the motion-picture and television industries require that, from time to time, the Society devote more or less of its energies to one phase or the other. The rapidly changing complexion of the industries makes this approach mandatory.

". . .today for every foot of film shot for entertainment purposes, considerably more feet are shot for other purposes: for education, for industry, for scientific research.

"The nontheatrical film field has fast become one of the most important areas of the motion-picture industry . . .the successful introduction of 8mm sound motion pictures during the past year portends a new age of nonentertainment utilization of motion pictures . . .the enormous capabilities of this new tool . . .indicate . . .merely the beginning of an expansion in this area of the industry that will involve tens of millions of 8mm sound machines.

"The technical improvements that brought about its introduction (8mm), the incorporation of the zoom lens, for instance, have provided amateurs with a flexibility in the making and projecting of films that was unheard of until now. The small business, in the past unable to afford to train its production and sales people in the preparation and projection of 16mm sound motion pictures, may now purchase simplified 8mm equipment, and, with a minimum of training and cost, have available to it sound motion pictures of its own making designed especially for its own use.

"In the public and private school systems, particular points in the teaching program may be illustrated with 8mm sound movies prepared by the staff . . . .

"The television industry appears to be following the pattern set by the motion-picture industry, that is, a medium which began as a purely entertainment medium is rapidly being applied to education, to industry, to business and to science.

"Educational television stations have mushroomed during the last few years, and field applications studies . . .have increased. . . . One of the greatest aids to educational television are the centers for laboratory testing of teaching by television, currently in use at many large universities . . ."

Mr. Servies cited the many uses of closed-circuit television in business and manufacturing and in government research and development and remarked that while television has already been put to many uses, it "will assume a far greater importance in the future."

"How many years will pass before commercial television reaches the stage that commercial motion pictures have reached where a larger percentage of television shows will be devoted to something other than entertainment, remains to be seen. However. . . such a day is coming. This does not mean that there will be less entertainment television. It just means that we will

GOSSEN
Lunasix®
ELECTRONIC

NOW!

THE MOST SENSITIVE... WIDEST-RANGE EXPOSURE METER EVER MADE!

The Gossen-LUNASIX Electronic is a precision exposure meter. With its unheard-of sensitivity, its extreme range (two complete scales for low and bright light), and its unmatched accuracy, the LUNASIX is destined to become *the standard exposure meter* for the critical still and movie photographer. ■ The LUNASIX measures light too dim for the human eye to read by—hence the instrument has an automatic needle lock. On the other hand, even in the most brilliant snow scenes—when other meters simply hit the end of the scale—the LUNASIX measures accurately with scale distance to spare! ■ Its incomparable performance is attained through a sophisticated electronic circuit which incorporates a specially designed photoconductive cell powered by a tiny long-life mercury battery. ■ The LUNASIX is the crowning pioneering achievement of West Germany's Gossen Company, the world's largest manufacturer of exposure meters with over 40 years experience and skill in the field of electrical precision measuring instruments.

SPECIFICATIONS: ■ Measures reflected and incident light (with built-in hemispheric diffuser) ■ For still and movie cameras ■ 30° light acceptance angle ■ Two-button brightness range system ■ Automatic needle lock ■ Built-in battery tester ■ External zero adjustment ■ Smooth one-hand operation ■ Computer range: ASA 6/1° to 12,000/12°; f/1 to f/90; 1/4,000th sec. to 8 hours; Cine: 8 to 128 frames per sec.; EV-9 to EV+22; .014 to 14,000 foot-candles ■ Weight: 7 ounces.

Other famous Gossen instruments...

1½-oz. Pilot ...tiny photoelectric precision exposure meter for reflected and incident light.

Sixticolor ...color temperature meter and filter indicator.

$63.00 including eveready case and neck strap at better camera stores

SOLE U.S. DISTRIBUTOR

KLING PHOTO CORPORATION • NEW YORK 10, N. Y. • HOLLYWOOD 38, CALIFORNIA

At the 8mm sessions. Left: Geo. W. Colburn, Chairman of the morning session, and Findlay J. Quinn, Vice-Chairman; right: John Flory, Topic Chairman and Chairman of the afternoon session, and E. W. Hamilton, Vice-Chairman.

see the addition of more educational television stations, which are being promoted and encouraged by educators everywhere.

"As we have done in the past, SMPTE stands ready to meet any new challenge that the industry produces. Through our engineering committees, through the *SMPTE Journal*, and through conventions such as this one, we intend to continue to strive for the advancement of the art of recording, storing and retrieving aural and visual events."

Mr. Fitzgibbons Discusses Telemeter

Keynote speaker John J. Fitzgibbons, Sr., who besides being President of Famous Players Corp., is also Vice-President and Director of Trans-Canada Telemeter, was introduced by Mr. Servies as "a pioneer of the Canadian motion picture industry."

Discussing "What's New in Exhibition," Mr. Fitzgibbons told the group that "the motion picture business is not a dead business." Confirming his statement with statistics, the speaker said that each week there are 2,500,000 theater tickets sold in Canada, despite the operation of 3,900,000 television sets reaching 92% of the Canadian population. He cited gross yearly intake of motion pictures as three billion dollars.

"We have every reason to believe," he said, "that we are in the right business."

Mr. Fitzgibbons said that despite the advances of television, he believes the motion-picture theater is still "the finest place" in which to see a film since a film may be "presented in a more satisfactory manner in a theater than anywhere else."

However, he maintained that there is enough room for both television and theaters "to perform a wanted service."

Summing up, the speaker said, "No person will dispute the fact that television is the greatest development in transmission of communications today."

Canadian Broadcasting Corp. Announcer Earl Cameron presented a lively account of the current news.

Session on Instrumentation. Immediately following the close of the luncheon, the afternoon technical session began with the screening of *Night at the Peking Opera.* Chairman Charles W. Wyckoff and Vice-Chairman Allen L. Sorem presided at this session on image-forming systems, instrumentation and high-speed photography.

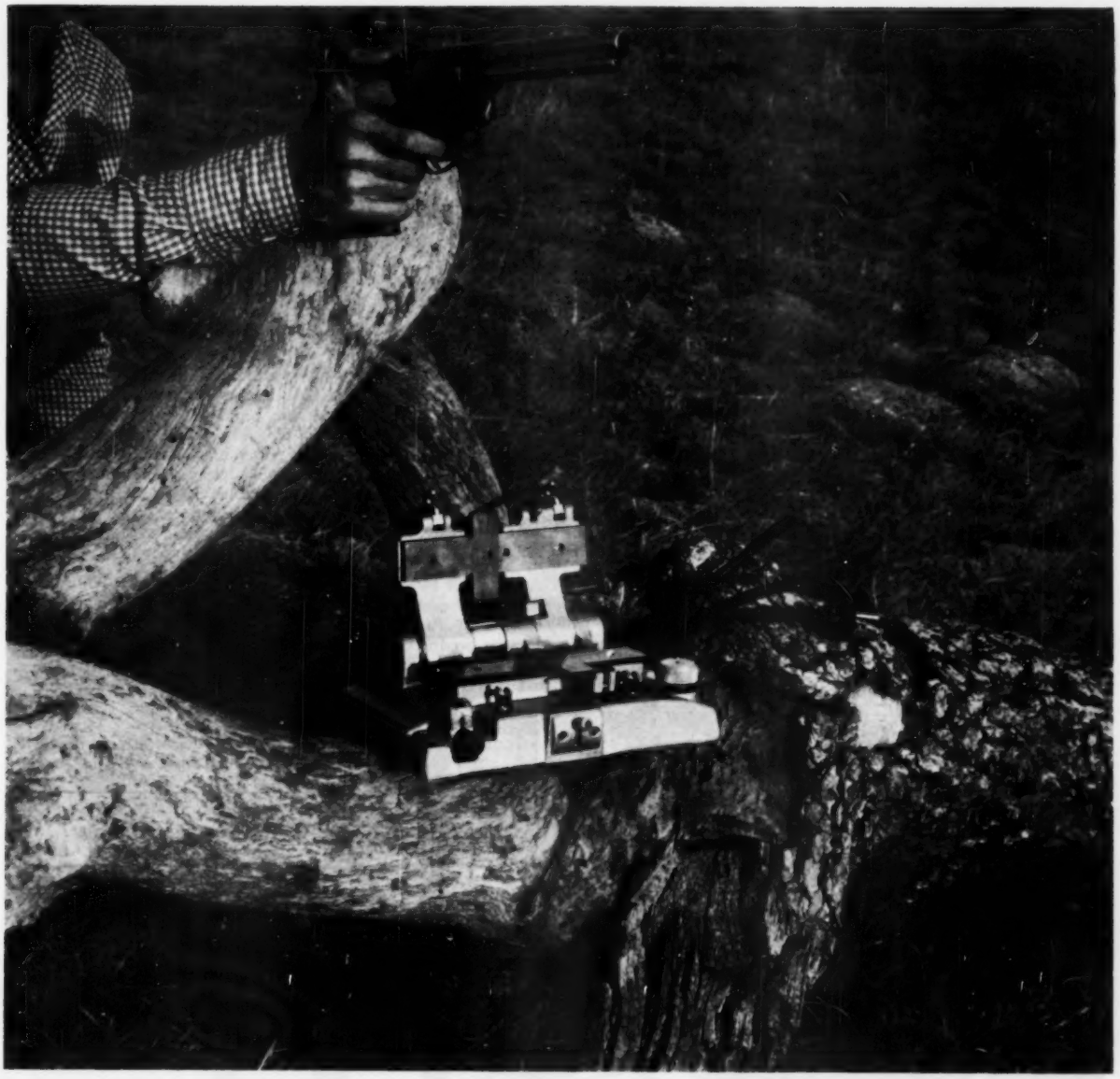
Films, TV in Education. Chairman Bernard Plakun and Vice-Chairman Leslie H. Holmes presided at the evening's session on Films and Television in Education which was opened with the showing of a Swedish film, *People of the City.* Delegates were told of the technical aspects of educational television in Detroit and in Cambridge, Mass. Representatives of the CBC discussed the positive results of their training course for TV technicians. Two papers dealt with communications in education.

8mm Session a Highlight. One of the convention highlights was the section of the program which treated new developments in 8mm sound motion pictures. These sessions on Tuesday were the best attended of the week with as many as 350 persons present. *Top Dogs,* an English short subject, opened the first 8mm session Tuesday morning. George W. Colburn, Session Chairman, and Findlay J. Quinn, Vice-Chairman, presided at this meeting. Delivering the first paper in which he called 8mm sound film "another milestone in the communications revolution," Kodak's John Flory predicted that this new development may extend the boundaries of the motion-picture industry just as paper backs have extended the field of publishing.

An historical résumé of the work of the late Lloyd Thompson was presented in this session; recent developments in 8mm sound projectors, cameras, and magnetic striping equipment were reviewed; the economical projection of 8mm magnetic film was analyzed; and a recently introduced endless loop magazine for projection of 8mm silent and magnetic film was described. Two educators discussed the requirements, potentialities and successes of 8mm sound film in education.

Full attendance at the 8mm sessions.

John Maurer asks a question.



The model that won the West...

Actually, the HFC Professional 16MM Hot Splicer didn't win the West in the sense that the Colt won the West, but it did win the praises of film editors not only in the West but around the world. Professional editors who demand professional equipment. Model shown: FS-816 (for 8 and 16mm). Other models available . . . FS-70-1 (for type #1 Military perforations) • FS-70-2 (for type #2 Military perforations) • FS-70-3 (for 65MM) • FSC-357 (combination splicer, 35 or 70MM) • FSC-657 (combination splicer, 16-35/32-65 or 70MM).

All models ready for immediate delivery.

The HFC Hot Splicers offer these features...

DOUBLE SCRAPING • LOSE ONLY HALF A FRAME • SEPARATE PROFESSIONAL SCRAPING BLOCK • LEFT TO RIGHT OR RIGHT TO LEFT SPLICING • MACHINE BLADES GROUND TO CLOSE TOLERANCES • NO DOWN TIME WHEN SCRAPING BLADES BECOME DULL • CHANGE BLADES IN SECONDS • CUSTOM BUILT CARRYING CASE • SPLICERS CAN BE SET FOR NEGATIVE, A & B OR RELEASE PRINTS • CUTTER BLADES CAN BE GROUND AND SHARPENED WITHOUT CHANGING SPLICE WIDTH • CUSTOM BUILT CASE

HOLLYWOOD FILM COMPANY

designers & manufacturers of film & video tape editing equipment

WRITE FOR FREE CATALOG: 956 SEWARD ST, HOLLYWOOD 38, CALIF. HO 2-3284 524 W. 43rd ST, N.Y., N.Y., LO 3-1546

8mm — Part II. The second portion of the 8mm section of the program took place on Tuesday afternoon under the direction of Topic Chairman John Flory and Vice-Chairman E. W. Hamilton. A 20-minute German short subject, *Capriccio*, was shown at the opening of the session. Papers were delivered which discussed a self-contained recorder, magnetic striping developments, the manufacture of 8mm prints, high-speed inspection of magnetic-striped release prints and photographic sound. A progress report on 8mm color positive release prints with magnetic sound was presented in this session.

A major portion of the 8mm papers is scheduled to appear in the next issue of the *Journal*.

Film Projection. Data on the energy absorption characteristics of color and black-and-white release film; and the historical development of the xenon light were among the reports presented in a session on Film Projection and Television Film, Tuesday evening. Eric C. Johnson and John G. Stott presided at this meeing which was told that the future of 70mm production was largely dependent on medium-sized theaters making it imperative that economy of installation be made a primary consideration. The problems of film-making in Canada, some of which are unique, were also discussed.

Sound Recording and Reproduction. The Wednesday morning and afternoon sessions, devoted to sound recording and reproduction closed early to allow delegates to prepare for the evening's entertainment gala. In the morning session, chaired by George Lewin and Leonard A. Green, an electronic tape recorder for special sound effects was introduced; multilingual and bilingual sound was discussed as well as the improvement of 16mm optical sound, modifications of tape producing equipment, re-recording applications, integrated audio systems and projection equipment. A Canadian short subject, *Operation Vulcan*, opened the meeting.

Richard Ranger and Leo H. O'Donnell presided at the afternoon session. A 20-minute German film *Jonny*, was screened at the beginning of this session. Papers were presented on two new equipments for producing artificial reverberation and on the design and operation of an instrument for oscilloscopic observation of frequency fluctations in the output of sound recording equipment. Two approaches to solving the television intercom problem were examined; a new 16-input fully transistorized audio console was introduced and a demonstration was given of bilingual and stereophonic recordings on 16mm film.

Lab Practices Discussed. A 20-minute Australian short subject, *Animal Parade*, opened the Thursday Morning Session on Laboratory Practices which was conducted by Arthur J. Miller and George J. Bova. Next to the 8mm session, this proved to be the second best attended session, with 250–300 present. Three papers from the Technicolor Corp. were presented in this session, including some excellent film presentations. Originating in London, Rome and Hollywood, these papers dealt with Technicolor's international facilities for release printing, arbitrary scales and selective printing. Delegates to this session were told also of a national network of processing laboratories for Kodachrome film; how color negative film surface characteristics affect picture quality; reversal color printing through masters; and a new process for rating the film speed according to location conditions.

William H. Metzger and John M. Waner chaired the second session on Lab Practices Thursday afternoon. Two English short subjects, *Cultured Ape*, and *Insolent Matador*, were shown at the beginning of the meeting.

Two papers on the rapid processing of motion-picture film by the application of viscous coatings were highlights of this session. Other topics dealt with were: fiber optics in the motion-picture laboratory; a medium-priced microdensitometer for photographic research; a sensitometer designed to make sensitometric strips for film investigation in the microsecond region. A high-speed continuous 16mm to 8mm reduction printer was discussed as well as a damping device to improve image sharpness and steadiness of prints made on a continuous 16mm motion-picture printer. The session was closed with a description of a method for determining the steadiness of printers independently of the steadiness of any projection used to examine the prints.

TV Recording. Television recording was the subject of the Thursday evening session,

an SMPTE publication

CONTROL TECHNIQUES IN FILM PROCESSING

Prepared by a Special Subcommittee of the Laboratory Practice Committee of the Society of Motion Picture and Television Engineers

WALTER I. KISNER
Subcommittee Chairman

Foreword by **E. H. REICHARD**
Chairman, Laboratory Practice Committee

CHAPTERS

1. Introduction
2. General Principles
3. General Aspects of Motion-Picture Film Processing
4. Mechanical Evaluation and Control
5. Instruments for Photographic Control
6. Control Strips and Sensitometric Curves
7. Sensitometric Control of a Standardized Process
8. Chemistry of Film Processing
9. Chemical Analysis and Control
10. Economic Considerations in Establishing a Process Control System

Two-page bulletin with description of subject matter of each chapter available without charge upon request to Society Headquarters

$5.00 Available only for cash with order or by Company Purchase Order
Single copy price $5.00 (less 20% to SMPTE Members, Libraries and Booksellers), F.O.B. Destination
5 through 49 copies at $5.00 each, less 25%, plus foreign postage, F.O.B. Origin
50 copies or more at $5.00 each, less 33⅓%, plus foreign postage, F.O.B. Origin
Within New York City Add 3% Sales Tax

Society of Motion Picture and Television Engineers 55 West 42nd Street, New York 36, N.Y.

pho-to-
in-stru-men-ta-tion ✳

✳ **The art and technique of utilizing photographic methods to establish graphic and visual proof of an experiment, test or investigation.**

That's CECO's definition of photo-instrumentation*

Your definition may be different. There's no doubt, however, about one thing . . . . CECO is the foremost source of the most current information on techniques and equipment utilized in this new science. CECO photo-instrumentation engineers are creating and adapting equipment for both industry and military to help them solve their recording and analyzing problems. ■ If you are faced with a problem, our engineers would like to work with you on it. Contact CECO today. There's no obligation, of course. ■ Your inquiries are invited on Photo-Instrumentation Equipment manufactured by CECO, Waddell, Bell & Howell, Traid, Flight Research, Zoomar, Wollensak, Hulcher, Vanguard, Mitchell, Arriflex and Maurer.

■ In Hollywood, California, 6510 Santa Monica Boulevard, HOllywood 9-5119
■ In Hialeah, Florida, 1335 East 10th Avenue, TUxedo 8-4604

CAMERA EQUIPMENT CO., INC.
Department JS-12, 315 W. 43rd St.
New York 36, N. Y., JUdson 6-1420

*CECO — Trademark of Camera Equipment Co., Inc.

Authorized Service Center for Beckman & Whitley MAGNIFAX (Eastman High-Speed) Cameras!!

1. RAPROMATIC FILM PROCESSOR FOR 16 AND 35MM CAMERAS: Revolutionary technique develops and fixes film instantaneously as you shoot. Superior image quality. Projects in seconds. Fits all cameras.

2. CECO WEINBERG-WATSON MODIFIED ANALYST PROJECTOR MODEL B. Absolutely flickerless from 1 to 24 pps. Instant transition from single frame to high speed, forward or reverse. Remote control. Holds single frame indefinitely without damage.

3. WESTINGHOUSE R-30 DESIGN HIGH-SPEED PHOTO LAMPS. Designed for high-speed instrumentation photography. Provides light equivalent to 45,000 foot candles at 12".

4. NEW WADDELL 16MM HIGH-SPEED CAMERA. A continuous camera employing the rotating prism as the means of optical compensation. Continuous film movement allows film to travel at greater velocities than normal intermittent cameras.

5. MAGNASYNC DATA AND INSTRUMENTATION RECORDERS. Record, play, "read" and "write" heads available with up to 16 channels for 35mm sprocketed or 1" audio tape. Speed range: 1/100" to 100" per sec. Can incorporate 6 different speed changes in one unit.

John A. Buist, Chairman of the Membership Committee, signing up a new member at the SMPTE booth.

A portion of one of the three rooms of commercial exhibits.

which was under the direction of Robert W. Byloff and Helmut Berger. *The Kitten*, a 20-minute West German short subject adapted in the United States opened the meeting.

A video-tape editing system was introduced in this session. Papers were also presented on a standard for positioning the vacuum guide in transverse track videotape recorders; time-base errors in magnetic television recorders; equipment and facilities of a complete recording service; TV standards conversion techniques; shutter-bar in kinescope recording; and a new TV film recorder capable of producing a high-quality 16mm film from the television system.

TV Practices. Thinking Machines, a United States film, opened the Friday morning session on Television Studio Practices and Station Operation. Chairman K. Blair Benson and Vice-Chairman L. J. Murch presided at this meeting during which papers from England, Belgium, Canada, the United States and Japan were read. Topics were production lighting controls; TV studio lighting and scenery handling; storage memorized light control; black-and-white TV picture monitoring and video levels; new TV camera tubes; picture characteristics of image-orthicon and vidicon camera tubes; and image-orthicon camera flicker.

Closing Session on TV. The final session of the Convention was devoted to Television Station Operation and Equipment. A Japanese short subject, *Tokyo Fantasy*, opened the session which was under the direction of Richard E. Putman and Maurice French.

Papers were presented on subjects including TV equipment and facilities in England; the technical organization of Eurovision; a computer control system for program switching; superimposed edging of television letters in Japan; a TV technical monitor; a progress report of European TV studio camera mounting; and a transistorized synchronizing signal generator.

The Convention was officially closed by Executive Vice-President Reid H. Ray who summed up the accomplishments of the week and the industry's indebtedness to the many who had made the program such a solid success. Courtesy of CBC, the session rang out with films of "O Canada!" and "God Save the Queen."

Committee Meetings

Nine of the Society's twelve engineering committees met during the Convention in addition to the Papers Committee, the Board of Editors, and the Publications Advisory Committee. There were several meetings of the Association of Cinema Laboratories during the last two convention days.

Closed Circuit

Operating continuously during the technical sessions was a closed-circuit television system which allowed delegates and visitors to be informed of what was being presented in the sessions auditorium. Monitors were placed in convenient locations in the hotel, including the registration, Coffee Club and exhibit areas. The equipment was made available and maintained through the courtesy of Pye (Canada) Ltd. under the supervision of Robert Hair.

Coffee Club

Between sessions delegates found the Coffee Club a pleasant retreat. Coffee and pastries were served during each day of the convention week. Canadian Kodak Company Ltd. sponsored the club.

Equipment Exhibit

The largest equipment exhibit ever assembled at an SMPTE convention, and matched in the Society's history only by the exhibit at the 5th Congress last fall, drew capacity crowds from Monday until Thursday when that area was closed. There were 54 display booths in four rooms.

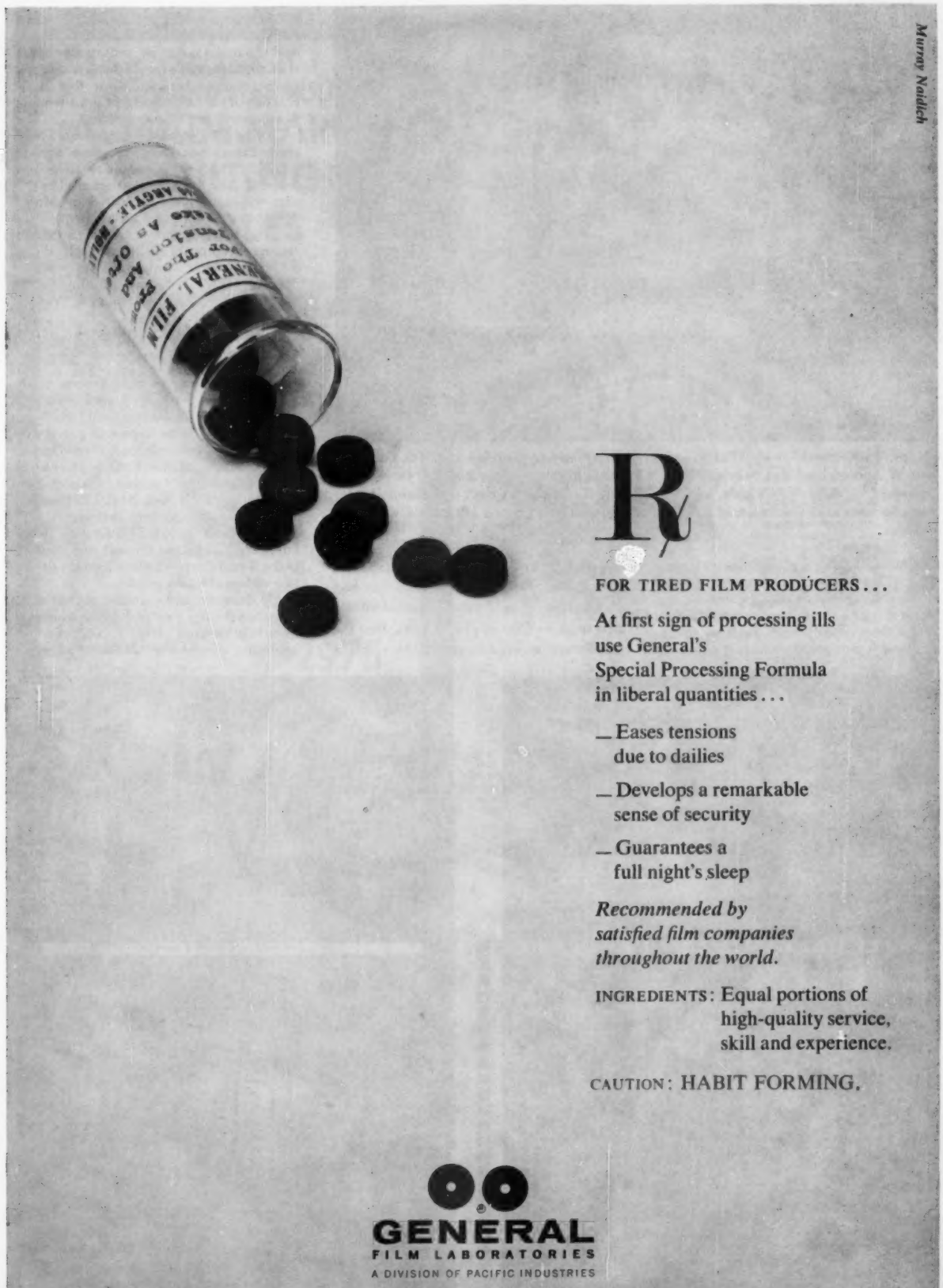
It is estimated that nearly 400 persons, in addition to the more than 900 convention registrants, visited the exhibit area where a wide array of new motion-picture and television equipment was being shown. Included among the exhibits were four representing the Canadian Government: National Research Council of Canada; National Film Board of Canada; Royal Canadian Air Force; and the Canadian Broadcasting Corporation.

The millions of dollars worth of equipment, which included satellite tracking cameras, film processors, lighting consoles, laboratory and studio devices, among other items, was representative of companies in the United States, Canada, England, Germany, France and Japan. Participating in the exhibit were the following companies:

Animation Equipment Corp.
A. T. R. Armstrong Ltd.
Beckman & Whitley, Inc.
Bell & Howell Co.
Behrend Cine Corp.
Braun of Canada Equipment Ltd.
Caldwell AV Equipment Ltd.
Camera Equipment Co.
Canadian Applied Research Ltd.
Alex L. Clark Ltd.
E. M. I.-Cossor Electronics Ltd.
Eastman Kodak Co.
Florman & Babb, Inc.
Harwald Co.
Hi-Speed Equipment, Inc.
Hollywood Film Co.
Philip A. Hunt Co.
Lipsner-Smith Corp.
Magna-Tech Electronics, Inc.
Mitchell Vinten, Inc.
Motion Picture Enterprises, Inc.
McCurdy Radio Industries Ltd.
Northern Electric Co.
Photo-Animation, Inc.
Precision Laboratories Div.
Robert Rigby Co. Ltd.
L. B. Russell Chemicals (Canada) Ltd.
See Cue Devices Ltd.
Strand Electric Ltd.
S.O.S. Cinema Supply Corp.
Thompson Products Ltd.
Viditon Corp. Ltd.
Wollensak Optical Co.

The exhibit space originally contracted for by the Society was sold out in January. In order to meet the great demand for space, it was found possible to obtain an additional room to house seven more booths. It was the consensus that the exhibits as a whole were easily one of the most attractive shows ever for an SMPTE meeting.

Great credit is due to the Exhibit Chairman, Kenneth S. Oakley, and to the members of his Committee, M. M. Elliott and Robert B. MacKenzie, for the work that


Murray Naidich
GENERAL FILM LABORATORIES
Rx
FOR TIRED FILM PRODUCERS...
At first sign of processing ills
use General's
Special Processing Formula
in liberal quantities...
_ Eases tensions
due to dailies
_ Develops a remarkable
sense of security
_ Guarantees a
full night's sleep
Recommended by
satisfied film companies
throughout the world.
INGREDIENTS: Equal portions of
high-quality service,
skill and experience.
CAUTION: HABIT FORMING.
GENERAL
FILM LABORATORIES
A DIVISION OF PACIFIC INDUSTRIES
1546 Argyle, Hollywood 28, Calif. / HOllywood 2-6171 / central division / 106 West 14th Street, Kansas City 5, Mo. / GR 1-0044

Reception line at the Cocktail Party. Left to right: Gerald G. Graham and Mrs. Graham; John W. Servies and Mrs. Servies; Charles S. Band, Member of the Board of Governors, National Film Board of Canada, and Mrs. Band; Guy Roberge, QC, Government Film Commissioner and Chairman of the Board, National Film Board of Canada, and Mrs. Roberge.

went into soliciting and organizing this fine show. With Customs requirements complicating the movement of all goods in and out of Canada there were more potential pitfalls than usually beset such an operation, and it was only by unusual efforts on the part of the Special Assignments Chief, Tex Rekert, such as the preparation and distribution of a detailed manual of instructions on Customs procedures, that the pitfalls were successfuly circumvented.

Careful watching of the administrative details during the days the exhibit was open and the maintaining of continuous contact with the representatives of the Customs and of the customs brokers, made this in the end one of the smoothest and most trouble-free shows SMPTE has ever had.

During the Wednesday afternoon Equipment Papers and Demonstrations Session, exhibitors had an opportunity to present some of their new developments. The session was admirably conducted by M. M. Elliott and Kenneth S. Oakley. Representatives of the following companies demonstrated equipment: Wollensak Optical Co.; S.O.S. Cinema Supply Corp.; Strand Electric Ltd.; Lipsner-Smith Corp.; Behrend Cine Corp.; Beckman & Whitley, Inc.

Social Highlights

The Wednesday evening entertainment started out in grand style with a cocktail party sponsored by the National Film Board of Canada. On hand to receive guests were Canadian Government Film Commissioner Guy Roberge and Mrs. Roberge; Gerald G. Graham and Mrs. Graham; Charles Band and Mrs. Band; and SMPTE President John W. Servies and Mrs. Servies.

Corsages for each lady attending the affair were distributed through the courtesy of the Ansco Corp. who provided the flowers in a variety of spring shades.

355 delegates and visitors and their wives attended the banquet and dance which followed the cocktail party. This occasion, ingeniously directed by Arthur Chetwynd,

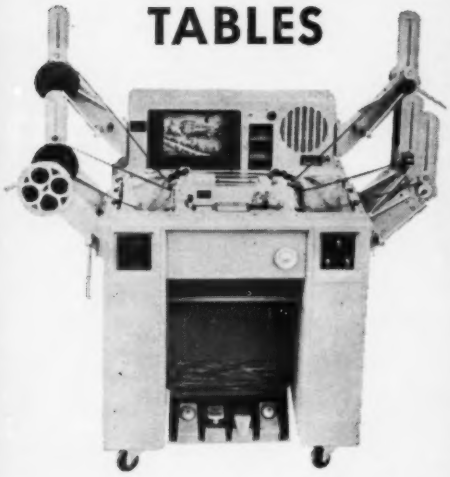
Canadian Government exhibits. Top: National Film Board of Canada, Royal Canadian Air Force; bottom: National Research Council of Canada, Canadian Broadcasting Corporation.

Serving the World's Finest Film Makers

NOW AVAILABLE AT F & B

ENGLAND'S FAMOUS

ACMADE MARK II EDITING TABLES



- 35mm and 16mm
- For Studios & TV
- Cutting and Viewing

Price complete and duty paid.

$2975

fob New York

- Continuous movement (non-intermittent) safer for negative or positive viewing.
- Synchronous and variable speed, instant stop, forward and reverse foot pedals and press button.
- Film paths instantly declutchable by switch selection.
- Projected picture 8"x6" or larger by removing screen.
- Separate magnetic and combined optical and magnetic heads.
- Built-in synchronizer footage counter and running time counter.
- Removable flange plate with tite wind roller.
- Instant sound track selector.
- Manual inching control.
- Fast rewind controls.

RECENT PURCHASERS:

J. Walter Thompson, New York; Safety Enterprises, Ohio; Sound and Scene Productions, Texas; Bay State Films, Mass.; Stamford University, California; Army Ordinance Corps, Maryland.

FLORMAN & BABB, INC.

68 West 45th Street New York 36, New York

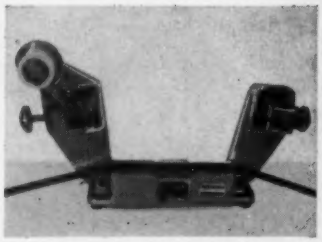
MUrray Hill 2-2928

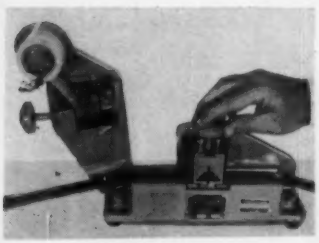
Another Fine Product From ACMADE

AUTOMATIC BUTT SPLICER

Cuts, Splices, Applies Magic Mylar Automatically!

The first practical, speedy and efficient automatic splicer and perforated adhesive tape (Magic Mylar) applicator on the market. Now, with no fuss, mess or waste, it is possible to splice, repair, butt-splice, or strengthen splices on all types of film—positive, negative, magnetic—even duPont Cronar or other bases.





The cutting arm, shown in operating position, is used by pressing the chrome button for cutting both sides of the film simultaneously. The film, of course, has been registered on pins in the horizontal channel. The cutting blade is easily replaced when necessary.

The splicing tape is registered on precision pins and held in place until automatically applied to the film by swinging the arm over and pressing the chromed button. This action simultaneously cuts the adhesive and applies it—in perfect register to the film.

Model 35 for 35mm

Model 16 for 16mm

$295

Write For Brochure

F & B MAGIC MYLAR

A new splicing and repairing technique.

NOW IN NEW 20 FT. ROLLS!

Only $2.20 for 16 mm; $4.04 for 35 mm

Please send me:

- ☐ 20 ft. rolls — transparent 16mm — single perforation (T16S) at $2.20
- ☐ 66 ft. rolls — transparent 16mm — single perforation (T16S) at $6.00
- ☐ 20 ft. rolls — transparent 16mm — double perforation (T16D) at $2.20
- ☐ 66 ft. rolls — transparent 16mm — double perforation (T16D) at $6.00
- ☐ 20 ft. rolls — transparent 35mm (T-35) at $4.04
- ☐ 66 ft. rolls — transparent 35mm (T-35) at $11.00
- ☐ 66 ft. rolls—white opaque—16mm—magnetic film only (0-16) at $6.00
- ☐ 66 ft. rolls — white opaque — 35mm (0-35) at $11.00
- ☐ ¼" splicing tape for magnetic tape (S4) at $.57

Name .....

Address .....

City .....

was hailed as one of the great successes of the week. The Canadian Broadcasting Corp., through Norman Olding, graciously provided entertainment for the affair, including performances by Juliette, Yoland-Guerard and the Mart Kenny Orchestra. Emcee Gordie Tapp conducted the show that was produced by Doug MacDonald and recorded for broadcast over the CBC Radio Network the following Friday. The Association of Motion Picture Producers and Laboratories of Canada kindly provided dinner wine.

During the week conventioneers had many occasions to appreciate the Pye closed-circuit equipment, and the photocopy service in the Press Room made available through the courtesy of Minnesota Mining and Manufacturing of Canada Ltd., The excellent short film subjects were kindly offered by Fremantle of Canada Ltd. E.M.I.-Cossor Electronics Ltd. and Minnesota Mining and Manufacturing of Canada Ltd. made available the magnetic tape used in recording the technical sessions.

Ladies Program

The interesting program for the ladies was planned in a flexible manner to allow plenty of free time for shopping and sightseeing. Photo Importing Agencies Ltd. gave a cocktail party for ladies and their husbands on Monday evening. Tuesday morning there was a trip to Niagara Falls and a luncheon at the Sheraton Brock Hotel, courtesy of Minnesota Mining and Manufacturing of Canada Ltd. That evening, the ladies attended "Front Page Challenge," a live television show, as guests of the Canadian Broadcasting Corp. Alex L. Clark Ltd. sponsored a flower show and tea at Toronto's showplace, the famed Casa Loma, later in the week.

Complimentary Theater Admissions

Complimentary theater passes were distributed to all delegates through the courtesy of Famous Players Theatres, Odeon Theatres, and Loew's.

Motion-Picture Record

Almost 2000 ft of 16mm black-and-white footage was exposed at the Convention by cameramen covering the important aspects of the week's activities. This record was made possible through the cooperative efforts of Don Virgo, George Sebb and Robert Brooks of Chetwynd Films Ltd., Toronto; Roger Beaudry of Pathe-DeLuxe Laboratories Ltd., Toronto; and Sydney Banks of S. W. Caldwell Ltd., Toronto. Film and laboratory processing were contributed by these three companies.

The film will be edited and released as a 12-minute sound short subject, and presented at the Lake Placid Convention next fall.

From all quarters, the 89th Convention in Toronto has been hailed as one of the most successful in the Society's history. Those who have worked on Conventions know that its success was possible because of the untiring efforts of our Canadian Section in charge of arrangements under the very able direction of Gerald G. Graham. The careful groundwork laid nearly two years before by Executive Vice-President Reid H. Ray, then Convention VP, contributed a great deal, as did the high caliber of work done by each person concerned with the Convention. Someone remarked in Toronto at the close of the week that the success of the meeting lay in the great capacity of those who worked on all aspects, and especially the "little" jobs, to take those jobs seriously and do them well. This, it is believed, sums up the reason behind the success.

A tremendous "Thank You" is offered to our northern members and a wish that SMPTE shall not wait another three decades to visit Canada. Within the not too distant future it is hoped that another Canadian convention may be scheduled.—*Barbara Skeeter.*

90th Convention, Lake Placid Club, New York. A brief note on the progress being made in planning the technical program of the Fall Convention will be found on p. 541 of this issue.

CRAMER Continuous Automatic Film Processor

Economically
EASIER
FASTER
BETTER

Only $835

LOOK AT THESE FEATURES:

- Low, low processing cost.
- Daylight operation.
- 16mm negative or reversal film processing.
- Handles up to 400 foot reels at 4 feet per minute—faster at elevated temperatures.
- Continuous flow fresh water rinse or static wash for portable operation.
- No installation cost.
- Compact, lightweight.
- Non-corrosive construction.

100' FASTAX COMBINED MOTION PICTURE AND OSCILLOGRAPHIC CAMERA

. . . the economy high speed camera. It features 100' daylight loading spools . . . speeds from 150 to 8,000 pictures per second. The WF-17 Fastax can take pictures or oscillographic recordings simultaneously or independently . . . three cameras in one.

WRITE for more detailed information and prices. Inquiries welcomed.

WOLLENSAK
OPTICAL COMPANY • ROCHESTER 21, N. Y.

in the east . . . it's

MOVIELAB

for color* and black & white

MOVIELAB FILM LABORATORIES
MOVIELAB BUILDING, 619 W. 54th ST.
NEW YORK 19, N.Y. JUDSON 6-0360

*developing color negatives • additive color printing • reduction printing including A & B • color slide film processing • blowups • internegatives • Kodachrome scene-to-scene color balanced printing • Ektachrome developing and printing • registration printing • **plus complete black and white facilities including cutting rooms, storage rooms and the finest screening facilities in the east.**

Education, Industry News

A sapphire-covered satellite is being constructed by Bell Telephone Laboratories as part of its satellite communication program for transoceanic transmission of television, telephone calls, data, and other communications. Working toward the long-range goal of communication satellites that can exist in space for 10 years or longer, thousands of pieces of man-made sapphires are being used to protect the satellite's solar cells from electron bombardment in space and to reduce the effects of proton bombardment. The solar cells, developed at the Laboratories, are small silicon wafers which have the property of converting sunlight to electricity. The cells, attached to the surface of the satellite, will be covered by slices of sapphire. Experimental satellites are being developed in two sizes, one 27 in. in diameter and the other 4 ft in diameter.

Statistics reported in the January 15, 1961, issue of *West Coast Contours*, an informational bulletin published by Chris Dunkle & Associates, 740 So. Western Ave., Los Angeles 5, show a total of 29,000 persons employed by the motion-picture industry in the Los Angeles-Long Beach metropolitan area during the month of November 1960, the highest monthly total since May 1947 the report states. Figures for total film attendance (in billions) show a decline from 3.5 in 1948 to 2 in 1958, with a rise in 1959 to meet the 1954 total of 2.2. The report also noted a rise in the average weekly attendance during 1959 amounting to 2.3 million over the 1958 total of 40.2 million.

An IBM 7090 electronic digital computer is used at Bell Telephone Laboratories, 463 West St., New York 14, to index scientific documents alphabetically, according to important words in the title. In one instance the computer indexed 1700 documents, according to title, author, number and project in 12 minutes. The titles are fed to the machine on punched cards, along with other cards containing the names of authors and identification numbers. The machine is then instructed to ignore "unimportant" words, and is programmed to scan the cards, reorganize the information and print out the index.

Plans for the Second Workshop-Seminar sponsored by Florman & Babb, Inc., have been announced. The first seminar was held June 12–15, 1960. (*Journal*, p. 444, June 1960.) The first Seminar was limited to 100 participants but expanded facilities, this year, will provide accommodations for 200. The date of the 1961 Seminar has not been announced (although announcement is expected shortly); nevertheless, in view of last year's response and the number of applicants who applied after the registration list was filled, the sponsors suggest that those wishing to attend the Second F&B Workshop-Seminar apply immediately to: Charles Lipow, Workshop-Seminar Coordinator, Florman & Babb, Inc., 68 W. 45 St., New York 36. There is no registration fee or other charge for attendance.

The four-day schedule (including evening sesssions) will include intensive discussions, workshop demonstrations and practice sessions. Roundtable discussions will include frame-by-frame technical analyses of animation films. Other activities will include special equipment exhibits, visits to animation film studios and surveys and evaluations of the latest animation techniques. Thirty animation experts have been selected to lead discussions and conduct demonstrations on various aspects of animation film production. Seminar schedules and materials are arranged with attention to the specific requirements of producers of animation films, representatives of industrial, university and government motion-picture departments, cameramen, and directors.

A four-day Animation Seminar and Work Shop to be held in November, 1961, has been announced by Photo Animation, Inc., 34 West Street, So., Mt. Vernon, N.Y. The meeting is planned to cover all phases of animation production from basic artwork to complete camera operation, including three-dimensional and multiplane animation and modern high-speed animation techniques. Persons attending will be given the opportunity of using equipment and making animation films. Each day's schedule will include morning, afternoon and evening sessions. Announced as "Second Annual Animation Seminar and Work Shop," there will be no charge for registration or attendance but attendance will be limited to approximately 100 persons.

OUR SERVICE & DEPENDABILITY KNOWN THE WORLD OVER

CAMART DUAL SOUND EDITOR

Model SB 111

- Edit single and double system 16mm or 35mm optical sound.
- Edit single system Magnastripe or double system magnetic sound.
- Use with any 16mm motion picture viewer to obtain perfect lip-sync matching of picture to track.
- Works from left to right or right to left.

Dual Editor (without viewer)..... $195.00
Zeiss Moviscop viewer..... $ 89.50
Special Editor-Viewer comb..... $269.50

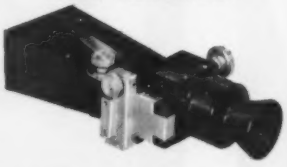
NEW DESIGN FILM BIN WITH RACK

- Rectangular construction
- Fits easily into corners
- Vulcanized fiber with reinforced metal frame.
- Complete Bin/rack linen bag w/skids.....$45.25
  w/wheels.....$51.75

ECCO MODEL D SPEEDROLL APPLICATOR

Cleans, conditions and lubricates your film in one easy operation. Non-inflammable, eliminates waxing, absolutely safe.

Ecco Model D Applicator.....$33.00
Ecco #1500 cleaning fluid per gal... $9.00
Ecco #2000 Negative cleaning fluid per gallon..... $7.00



MACO VIEWFINDER

- A professional viewfinder—you shoot with both eyes open.
- Same design and operation as used on feature work.
- Special mounting brackets for Cine Special 1, 11, Bolex H-16 Bolex Octameter, B & H Series 70, B & H Specialist, Arriflex.
- Includes inside angle lens and adapter and mattes for two lens fields.

$145.00

Send for new 1961 Catalog

the CAMERA MART inc.
at Columbus Circle next to New York's new Coliseum

Spotlight on

Gevapan 36, Type 191 is an extremely sensitive panchromatic film, favared by experienced cameramen the world over. It is especially suited for newsreel and other cinematography under the most adverse lighting conditions.

Gevapan 36 offers an excellent balance of very high speed and relatsvely fine grain. It is an excelleht all-around film favored by many fot use under normal lighting conditiyns, as well; used in this way, Gevapan 36 permits use of smaller apertures to obtain much greater depth of focus when desired.

Negative films
Duplicating fiims
Sound Recording films
Positive films
Reversal films
Gevacolor films
Magnetic film

GEVAERT **Offers a complete line of quality photographic materials**

GEVAERT PHOTO-PRODUCTEN N.V., 27 SEPTESTRAAT, MORTSEL (ANTWERP) BELGIUM

In the U. S.: The Gevaert Company of America, Inc., 321 West 54 Street, New York 19
In Canada: Photo Importing Agencies Ltd., 345 Adelaide Street, West, Toronto 2B, Ontario

A training conference on the operation and servicing of transistor sound systems, held recently at the factory of the Century Projector Corp., 729 Seventh Ave., New York 19, was conducted by Gio Gagliardi, Chief Engineer of Stanley Warner Theatres. The new transistorized sound systems (Century multiple channel (6-4-1)) are being installed in a number of the Stanley Warner Corp. theaters.

The Association of Cinema Laboratories, comprising some 60 commercial motion-picture laboratories throughout the country, held several meetings in Toronto during the recent SMPTE 89th Convention there and has announced a considerably expanded program of activities. Among these will be studies to improve the industry's technical practices, the quality and performance of its products, and its relations with government in such areas as product specifications, taxation and related matters.

To coordinate this work, the ACL has appointed as Executive Secretary *Preston B. Bergin*. Mr. Bergin will be at the ACL office, 1925 K Street, N.W., Washington 6, D.C.

The various parts of the ACL's program will be shaped by a number of Standing Committees whose titles and chairmen are: Government Affairs, *James A. Barker*, Capital Film Laboratories, Inc.; Nominating, *William E. Gephart, Jr.*, General Film Laboratories, Inc.; Trade Practices, *Sidney P. Solow*, Consolidated Film Industries; Product Specifications, *Garland C. Misener*, Capital Film Laboratories, Inc.; Membership, *Saul Jeffee*, Movielab Film Laboratories, Inc.; Publications, *Reid H. Ray*, Reid H. Ray Film Industries, Inc.; Technical Practices, *Fred Scobey*, General Film Laboratories, Inc.; Program, *G. Carleton Hunt*, General Film Laboratories, Inc.

ACL's current officers are *Byron Roudabush*, Byron Motion Pictures, Inc., President; *G. Carleton Hunt*, General Film Laboratories, Inc., Vice-President; *Louis Feldman*, Du Art Film Laboratories, Inc., Treasurer; and *Dudley Spruill*, Byron Motion Pictures, Inc., Secretary.

FS T.M. REG.

3-LIGHT
Additive Color
COMPENSATING HEAD

Supplied to fit existing machines of Bell & Howell Continuous Printer Models D & J. and Depue-Carlson Step Printer

To fit Bell & Howell Models D & J . . . $5,100
To fit Depue-Carlson Step Printer . . . $4,100
(F.O.B. New Rochelle, N. Y.)

Used by: Pathe Labs.
Movielab Color Corp.
Color Service Co.
General Film Labs.
Consolidated Film Inds.
Alexander Film Co.
Deluxe Laboratories
U. S. Signal Corps.
Patrick Air Force Base
Calvin Productions, Inc.

This 3-light additive color unit supplies discrete blue, green and red beams. No one beam contributes to contamination of the others.

Solenoid operated, calibrated neutral density glass filters. Five filters in each color beam, giving 32 printer steps of .025 or .030 Log E.

High efficiency interference-type dichroic beam splitters to form a single mixed output beam.

Colored glass and/or high efficiency interference-type trimming filters, "peaked" to the positive stock sensitivity.

Printing speed up to 125 feet a minute for continuous printing: 55 feet a minute for step printing.

Three 750-watt bulbs, operating at 60–80 volts. Assures long bulb life, saving time in calibration.

Adjustable lamp sockets to line up filaments. Three degrees of freedom; vertical, rotational, lateral.

Four-leaf adjustable diaphragm, imaged at the printing aperture which provides an optical printing aperture for exposure and/or uniformity control (on units to fit Bell & Howell Models D & J only).

AVAILABLE ACCESSORIES

3-Channel Memory Unit with Reader for automatic operation of flipper assembly, reading in succession blue, green, red and storing the introduced information. 15 neon pilot lights indicate when the 15 neutral density filters are in or out so that operator can see at a glance if Reader and Memory Unit are functioning properly. For easy servicing, commercially available punched tape reader is used as a base. Price: $3,200 F.O.B. New Rochelle, N. Y.

Keyboard and Punch with 32 combinations for each color; blue, green, red; with an additional channel for introducing other information such as stop, lap dissolves, etc., and with built-in scene counter. Can also be used with Reader to reproduce automatically duplicate tapes and will permit corrections of the tape and continue with the accepted information. Price: $2,300 F.O.B. New Rochelle, N. Y.

Write for further information

FISH-SCHURMAN CORPORATION, 85 Portman Road, New Rochelle, N. Y.

The Annual Conference of the University Film Producers Association will be held August 20–26, at the University of California, Berkeley. Meeting with the UFPA Conference as Conference guests will be the Congress of the International Schools of Cinema and Television. Last year's Congress, which was attended by Charles N. Hockman, UFPA President, was held in Warsaw-Lodz, Poland.

The 13th International Congress on Motion-Picture Engineering, sponsored by the Associazione Tecnica Italiana per la Cinematografia (ATIC), will be held September 24–27, 1961, in Turin. This year, the Congress will be host to the 4th Congress of UNIATEC (International Association of Motion-Picture Engineering Societies), of which ATIC is a member.

The theme of the technical program will be: Evolution and Orientation of Motion-Picture Techniques as a Function of Basic Scientific Principles. Abstracts should be submitted by July 22 and manuscripts by August 5 to the XIII Congress International de la Technique Cinematographique, 60 Corso Galileo Ferraris, Turin, Italy. Other information, including hotel reservations, is available from the same address.

The Motion Picture Division of the Photographic Society of America has announced the 3d Annual Ten Best International Cinema Competition. Films entered in the PSA-sponsored contest may be in black-and-white or color and there are no restrictions as to width or length. Both silent and sound films are acceptable and a competing film may be produced by an individual or by a group. Entries are placed in one of two categories — amateur and commercial. The PSA Gold Medal is awarded for the best amateur film and other awards are granted for films in the amateur category. The film judged to be the best in the commercial category is recognized by presentation of an Award of Merit. August 15 has been set as the deadline for entries. Additional information is available from Charles J. Ross, 3350 Wilshire Blvd., Los Angeles 5.

Three Fellowship Awards and three Senior Memberships were announced at the Annual Banquet of the Society of Photographic Scientists & Engineers held May 25, 1961, in Binghamton. N.Y. The three newly named Fellows of the SPSE, so

THE BACH Auricon LINE OF 16MM PROFESSIONAL CAMERAS

"CINE-VOICE II"
100 FT. RUNS 2-3/4 MIN.
$967.00 & UP

AURICON "PRO-600 SPECIAL"
400 FT. RUNS 11 MIN.
$1295.00 & UP

AURICON "PRO-600"
600 FT. RUNS 16-1/2 MIN.
$1456.25 & UP

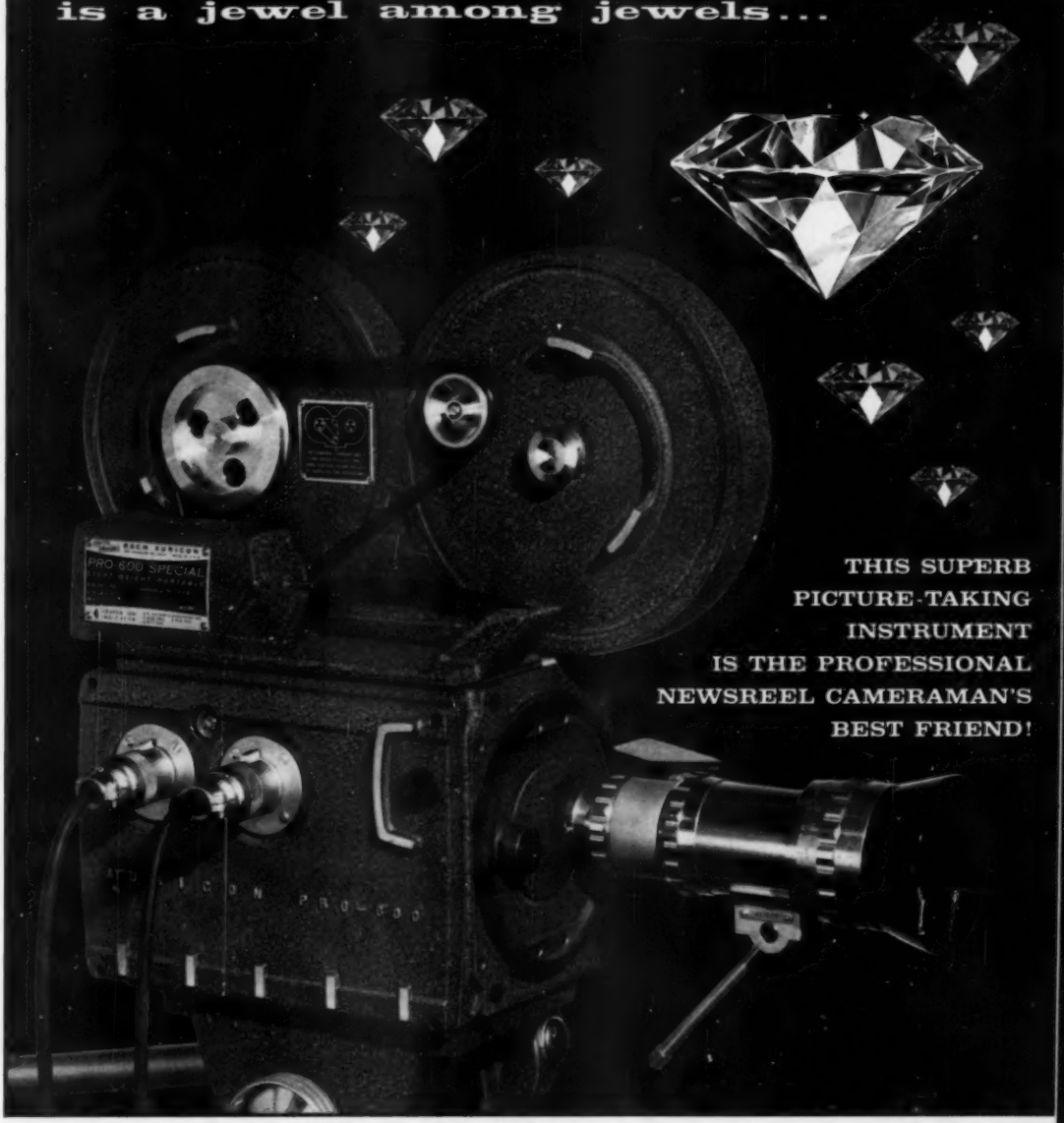
AURICON "SUPER-1200"
1200 FT. RUNS 33 MIN.
$4149.00 & UP

GUARANTEE

All Auricon Equipment is sold with a 30-day money back Guarantee and a 1 year Service Warranty. You must be satisfied!

WRITE FOR YOUR FREE COPY OF THIS 74 PAGE AURICON CATALOG

The Auricon "Pro-600 Special" is a jewel among jewels...



THIS SUPERB PICTURE-TAKING INSTRUMENT IS THE PROFESSIONAL NEWSREEL CAMERAMAN'S BEST FRIEND!

ALL OVER THE WORLD, PROFESSIONAL NEWSREEL CAMERAMEN HAVE ACCLAIMED THE AURICON "PRO-600 SPECIAL" FOR ITS PRECISION AND DEPENDABILITY UNDER RUGGED FILMING CONDITIONS!

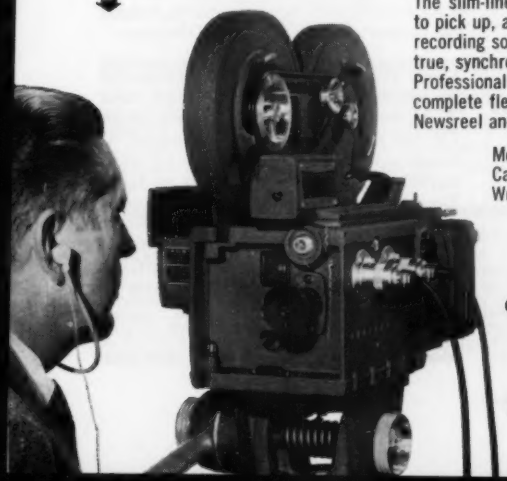
The great majority of Newsreel Cameramen prefer the Auricon "Pro-600 Special" for the production of 16mm Newsreels and Documentary films. This superb picture-taking instrument, with all of its many built-in professional features, weighs only 24 pounds "ready to travel," yet gives you a choice of 400 or 600 feet of film, with ultimate portability!

The slim-lined "Pro-600 Special" is Self-Blimped for completely quiet operation, so there is no noise for the microphone to pick up, and no need for the heavy, bulky, sound-proof enclosure "blimp" required by all other 16mm cameras when recording sound. The "Pro-600 Special" records Optical or "Filmagnetic" Single-System sound. Because it is driven by a true, synchronous motor, it is also ideal for Double-System sound recording, as well. All of the many Auricon Professional accessories can be added when needed, for field or studio filming, without the use of tools . . . giving complete flexibility! The Auricon "Pro-600 Special" is the perfect answer for large film-capacity Newsreel and Documentary filming . . . with light-weight portability!

More than any other camera ever built, the "Pro-600 Special" has become firmly established as the Newsreel Cameraman's "best friend," because of its jewel-like Quality and proven high Reliability.
Write for free, illustrated Auricon Catalog fully describing this "jewel among jewels."

GET BEHIND AN AURICON "PRO-600 SPECIAL"...

. . . and know the real satisfaction of filming with a truly Professional Camera!



BACH AURICON, Inc.
6946 Romaine St., Hollywood 38, California
HOLLYWOOD 2-0931

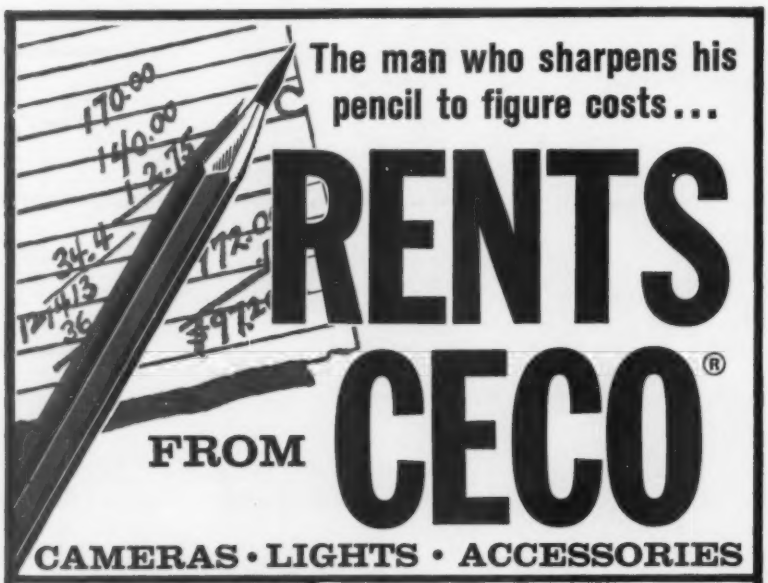
OVER 30 YEARS OF PROGRESS
BACH Auricon
1931-1961

AURICON . . . THE PROFESSIONAL CAMERA · STANDARD OF THE 16MM SOUND INDUSTRY SINCE 1931

honored for "contributions to photographic science and engineering," are: Frank Back, President of Zoomar Corp.; Heinz F. Nitka, Associate Director of Research and Development, Ansco Division of General Aniline & Film Corp.; and Robert S. Quackenbush, Jr., honored for "early work in the field of aerial photography and interpretation." A former commander of the Naval Air Station at Key West, he is now a special technial representative for Polaroid Corp.

The three newly named Senior Members are: George T. Eaton, a founding member and first SPSE President. He is Assistant Head of the Applied Photography Division of Kodak Research Laboratories; Ira R. Kohlman, Conference Coordinator for SPSE and Manager of Technical Services for LogEtronics, Inc., Alexandria, Va.; and Joseph Mangiaracina, Chief Instructor and Training Administrator, U.S. Army Signal School, Fort Monmouth, N.J. He was cited for "exceptional work on behalf of SPSE."

The Fifth Annual International Film Festival will be held November 1–14, at the Metro Theatre, San Francisco. The Festival has received official recognition from the International Federation of Film Producers Association and representatives of 61 countries have been invited to participate. Additional information is available from The Editor, Festival Footnotes, San Francisco International Film Festival, 172 Golden Gate Ave., San Francisco 2, Calif.


The man who sharpens his pencil to figure costs...
RENTS
FROM CECO®
CAMERAS • LIGHTS • ACCESSORIES
Cameras: 16mm & 35mm—Sound (Single or Double System)—Silent—Hi-Speed—Instrumentation
Lighting: Arcs—Incandescents—Spots—Floods—Dimmers—Reflectors—All Lighting Accessories
Generators: Portable—Truck Mounted
Sound Equipment: Magnetic—Optical—Mikes—Booms
Grip Equipment: Parallels—Goboes—Other Grip accessories
Cranes, Dollies: Crab—Western-Portable Panoram
Lenses: Wide angle—Zoom—Telephoto—Anamorphic
Editing Equipment: Moviolas—Viewers—Splicers—Rewinders
Projection Equipment: 16mm & 35mm—Sound & Silent—Slide—Continuous
Television: Closed Circuit TV
Camera Cars:
® TM #707529
In Hialeah, Florida:
Camera Equipment Co., Inc. of Florida
1335 East 10th Ave • TUxedo 8 4604
It makes sense, it saves dollars to rent from CECO. What's your problem? — a 6-second ID or a giant spectacular? CECO's store rooms are bulging with the world's finest and newest photographic equipment.
Everything is checked out to perform "better than new". All normal servicing is provided FREE. Ask your accountant why you save money when you rent instead of buy. For quick action, call JUdson 6-1420 — today!
CAMERA EQUIPMENT CO., INC.
315 W. 43rd St., N. Y. 36, N. Y. JUdson 6-1420
Camera Equipment Co., Inc.
Dept. JS 15, 315 W. 43rd St., N. Y. 36, N. Y.
Gentlemen: Please rush me your FREE complete catalogue of Rental Equipment.
Name
Firm
Street
City Zone State

The Fourth Annual Motion Picture Workshop of the Department of Television, Motion Pictures and Radio, New York University, Washington Square, New York 3, will be held July 24 – September 1, 1961. The workshop is an intensive six-week course in professional production, direction and writing, primarily for motion-picture students, special students and teachers, and professionals desiring complete production-direction experience. Emphasis is on creative film making. Enrollment is limited to 30 and the fee is $335.

A new photoinstrumentation unit to provide specialized photographic services for research laboratories on a company-wide basis has been established in the Nuclear and Basic Research Laboratory of the Dow Chemical Co., Midland, Mich. R. Wayne Anderson has been appointed Research Photographer in charge of the new unit. Mr. Anderson, author of two papers presented at the Fifth International Congress on High-Speed Photography ("High-Speed Photography Using Ultraviolet Light to Eliminate Visible Light Masking in Self-Illuminating Events," and "Value Received — The Use of High-Speed Photographic Techniques in Research and Industry"), has been with the firm since 1945. Techniques to be used by the new unit include high-speed and time-lapse photography, photocinemicrography and photocinemacrography, and infrared and ultraviolet photography.

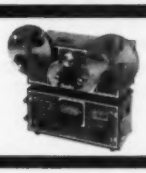
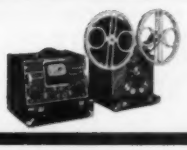
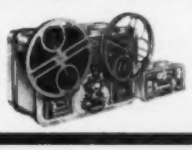
An experimental electronic system that can help a composer to create new music by suggesting variations and new tone combinations based on his original ideas has been developed by Radio Corp. of America. This electronic composer's assistant is a special-purpose type of computer called a "random probability" system. It consists of an arrangement of circuits designed to select notes in random fashion from among many choices, with the probability of the choice determined by the frequency with which various note sequences occur in the style favored by the composer. The composer sets the pattern of the controlling circuits, then the computer may range over the many possible variations that may be used to develop the basic theme. The machine, in a laboratory demonstration, produced original tunes in the style of Stephen Foster, guided by circuit arrangements based on the melodic and rhythmic characteristics of Foster's music. Rearrangement of the circuits would provide variations on any other style of music favored by the (human) composer, including unconventional scales and rhythms.

A new firm specializing in the design and production of electromechanical and electronic accessories for closed-circuit TV has been announced by Leonard T. Winship, former Manager of the TV Sales Application Engineering Group of GPL. The new firm, called Nassau Laboratories, is temporarily located at 42 Valley Road, Plandome, L.I., N.Y. Products immediately available include video switches, video distribution amplifiers, weatherproof housings, and similar items.

Michael W. Chitty has been appointed

*How to select a recorder to start your MAGNASYNC-MAGNAPHONIC SOUND SYSTEM

Sound Equipment Checklist

		SPLIT 16 MM FILM	16 MM FILM	17½ MM FILM	35 MM FILM	REWIND	FOOTAGE COUNTER	POWER AMPLIFIER	MONITOR SPEAKER	TORQUE MOTORS	PLUG-IN AUDIO	PUSH BUTTON CONTROL	REMOTE CONTROL	SLIDE-WIRE POTS	FILM MONITOR	SYNKINETIC MOTION	PLUG-IN HEADS
Nomad MARK 1		X													X	X	
Nomad MARK 11		X													X	X	
X-400			X			X	OPTIONAL	OPTIONAL	OPTIONAL						X	X	OPTIONAL
TYPE 1			X	X		X	X	X	OPTIONAL		X				X	X	OPTIONAL
TYPE 15			X			X	X	X	X	X					X	X	OPTIONAL
TYPE 5			X	X	X	X	X	X	X	X	X				X	X	OPTIONAL
MARK 1X			X	X	X	X	X	X	OPTIONAL	X	X	X	X	OPTIONAL	X	X	X

There is nothing on the market that compares with the remarkable Mark 1X. This unit is in a class by itself . . . with push-button remote controlled relay functions, plug-in audio elements and all the "extras" that make for flawless recording under the most adverse conditions.

From $2145.

*Regardless of the model you select, you can always depend upon equipment with the "Magnasync-Magnaphonic" label . . . equipment made by the international leaders in the design and manufacture of quality magnetic film recording systems.

MAGNASYNC Synchronous Film Recorder — Magnaphonic Sound System

Write, wire or phone

MAGNASYNC CORPORATION

5546 Satsuma Avenue, North Hollywood, California
TRiangle 7-0965 • Cable "MAGNASYNC"

Magnasync Studio Equipment Division Dealers:

CHICAGO: Zenith Cinema Service, Inc.; Behrend Cine Corp.; **LOS ANGELES:** Birns & Sawyer Cine Equipment; **NEW YORK:** Camera Equipment Co.; Pictronics Corp.; **SAN FRANCISCO:** Brooks Camera; **SOUTH AFRICA:** Johannesburg, Photo Agencies Pty. Ltd.; **AUSTRALIA:** Sydney, New South Wales, Sixteen Millimetre Australia Pty. Ltd.; **BOLIVIA:** La Paz, Casa Kavlin; **BRAZIL:** Rio De Janeiro, Mesbla, S.A.; **BURMA:** Rangoon, G. K. Theatre Supply Co., Ltd.; **CANADA:** Toronto, Ontario, Alex L. Clark, Ltd.; **DENMARK:** Copenhagen, Kinovox Electric Corp.; **ENGLAND:** London, W-1, Delane Lea Processes, Ltd.; **FRANCE:** Paris, Brockliss-Simplex S.A.; **GERMANY:** Hilden, Dusseldorf, Gerhard Johansen; **GREECE:** Athens, Christos Axarlis; **HONGKONG:** Supreme Trading Co.; **INDIA:** Bombay, Kine Engineers; **ITALY:** Rome, Reportfilm, di J. M. Schuller; **JAPAN:** Tokyo, J. Osawa & Co., Ltd.; **NEW ZEALAND:** Auckland, Kerridge Odeon Industries; **PAKISTAN:** Karachi 3, Film Factors Ltd.; **SOUTH RHODESIA:** Salisbury, William Over & Co. Pvt. Ltd.; **THAILAND:** Bangkok, G. Simon Radio Co., Ltd.

STRICTLY PERSONAL

Yes! We have the most modern equipment to print your film. But all the equipment in the world won't guarantee you highest quality prints. This requires the personal attention of skilled craftsmen.

The master craftsmen at Motion Picture Laboratories have the keen minds, the imagination, the know-how gained from years of experience, and the personal integrity to give you prints of matchless excellence.

We don't "mass-produce" prints here. We print your film on a strictly personal basis, giving it "everything we have" to give you the finest prints money can buy. That's one more reason why our clients have remained steadfastly with us through the years.

As for speed, MPL gives you 24 hour delivery service anywhere in the United States.

Send your film by AIR—today.

SOUND—EDITORIAL
COMPLETE LABORATORY SERVICES

MPL

MOTION PICTURE LABORATORIES, Inc.
781 S. Main Street • Memphis, Tennessee
Phone—Memphis WH 8-0456

The Master Craftsmanship Your Film Deserves

Chief Engineer for Reevesound Co., a subsidiary of Reeves Soundcraft Corp. He was formerly Division Manager for Canadian Marconi Ltd. In his new post he will inaugurate and supervise a general program of product engineering.

Frank A. Comerci has been appointed Manager of the Magnetics Research Department of CBS Laboratories, Stamford, Conn. Prior to his present appointment he was Senior Electronics Engineer with Audio Devices, Inc. He has also been associated with Rangertone Corp. and later joined the Naval Material Laboratory, Brooklyn, N.Y., where he was head of the Acoustics and Communications Section.

John C. Pennock, a Vice-President of Flight Research, Inc., Richmond, Va., has been appointed Manager of the firm's new Western Division, 2121 C Placentia Ave., Costa Mesa, Calif. Donald Bass has been elected a Vice-President and will succeed Mr. Pennock as head of Application Engineering, which has been transferred from Richmond to the firm's New York office at 116–55 Queens Blvd., Forest Hills, N.Y. The new appointments were made as part of the firm's expansion program in the photoinstrumentation field. Expansion plans include emphasis on photographic data acquisition equipment and exploration of related nonphotographic techniques.

John W. Lang, Jr., has been appointed Manager of Design for the Photo Products Division of Bell & Howell Co. He has been with Bell & Howell since 1954, and, earlier, held the post of Assistant Chief Engineer for DeVry Corp.

Arthur E. Thake has been appointed General Manager of Manufacturing Engineering, Photo Products Division, Bell & Howell Co., Chicago. He has been with Bell & Howell since 1950, first as Chief Optical Production Engineer, and later he was given successive appointments as Assistant Director and Chief Engineer of the Optical Division, followed by an appointment in 1960 to the post of General Manager of the Government and Special Products Division.

Rodney D. Chipp & Associates, Consulting Engineers, 15 Ward St., Bloomfield, N.J., is a newly organized firm equipped to offer consulting services on an international as well as a nationwide scale in the fields of electronics, communications systems, radio and television broadcasting systems, industrial TV and engineering management. Consultation services include planning, design, construction, operation, maintenance and management of the various systems. Head of the new firm is Rodney D. Chipp whose extensive background in engineering has included an appointment (with his wife, Dr. Beatrice A. Hicks) to Project Ambassador, sponsored by the National Society of Professional Engineers. This assignment involved a detailed survey and report on problems faced by engineers overseas, with a view toward improving intercontinental relationships on a scientific and engineering level. He has also traveled widely on other engineering projects. An engineering executive at International Telephone and Telegraph Corp., he resigned his post to head the new firm. His engineering background also includes many years with National Broadcasting Co. and the Allen B. DuMont Laboratories. In addition to developing operational equipment and techniques he has also engineered large-scale military communications systems and has previously been retained as consultant to military and civilian governmental agencies as well as many large industrial organizations.

Mediterranean Studios Association (MSA), a newly organized production company, reportedly backed by the governments of Greece, Morocco and Turkey, will utilize the services of the Anzervos Studios in Athens; Souissi Studios in Rabat, Morocco; and Fitas Studios in Istanbul, Turkey. Organized by Motion-Picture Director Marion Gering, formation of the new company was announced at the Cannes Film Festival. According to Mr. Gering, plans are to employ American as well as native actors and directors, and to make the new company's facilities and services available to other companies in the film industry.

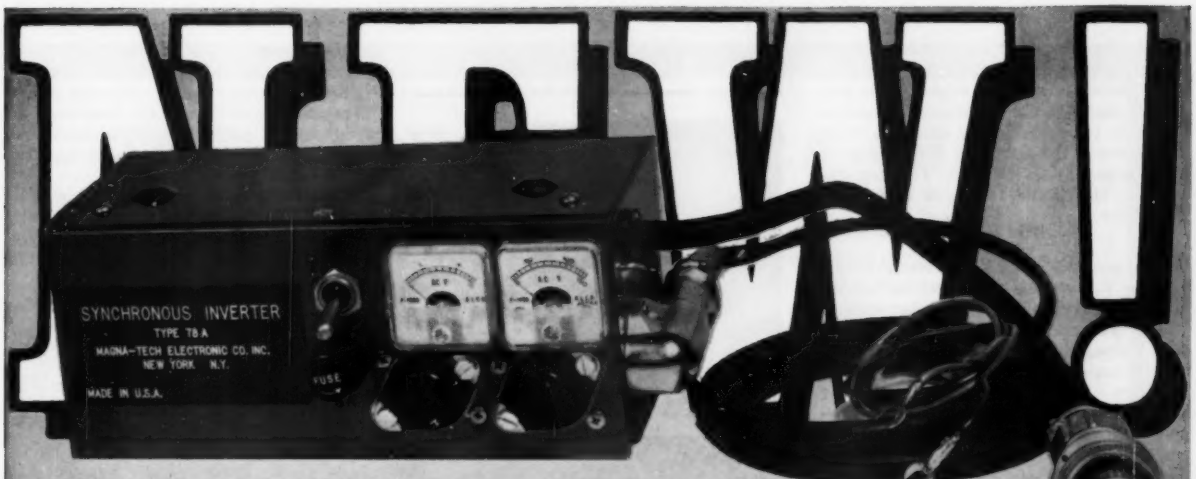
Aerol Associates, Inc., 9024 Olympic Blvd., Beverly Hills, Calif., has been appointed national sales representative for closed-circuit TV and data transmission equipment manufactured by American Microwave and Television Corp., 1369 Industrial Rd., San Carlos, Calif. The equipment includes four types of vidicon cameras, microwave transmissions systems and a newly developed system for transmitting documents over closed-circuit TV.

Establishment of a new district office for closed-circuit TV equipment sales activities in General Electric's Communications Sales Center, 565 Broadway, Redwood City, Calif., has been announced. Head of the new office will be Raleigh E. Utterback who has been appointed West Coast District Manger for closed-circuit equipment sales of General Electric Technical Products Operation. The Technical Products Operation, which is part of the GE Communication Products Department, manufactures closed-circuit TV systems and equipment. Other products include special projection and display devices and broadcast equipment.

Purchase of a nationwide network of new Eidophor television projectors for large-screen closed-circuit TV has been announced by Theatre Network Television, Inc. (TNT), 575 Madison Ave., New York 22. Reportedly the largest single contract in the history of closed-circuit television, the agreement between Ciba, which manufactures the Eidophor, and TNT involved more than $600,000. TNT plans to install the new projectors in all major markets in its network.

Cinebox, the Italian-born, sophisticated granddaughter of the raucous old jukebox, is an "automatic sound-motion picture unit for showing selections of short films in public places." Coin-operated, it can, if desired, be adapted to free institu-

M.T.E.



SERIES 78 BATTERY-POWERED SYNCHRONOUS INVERTERS
provide a source of 115V A.C. 60 cycles for synchronous operation of equipment in the field. A 10 minute take made with cameras and film recorders driven from these Inverters will be in precise lip-sync ±¼ frame. 50 Watt thru 500 Watt models are available for driving all cameras, such as Mitchell, Arriflex, Auricon, etc. or any film recorders. All solid state, the unit pictured above, Type 78A, 50 Watts, weight 5 pounds.

SERIES 88 BATTERY-OPERATED SYNC TRACK GENERATORS for recording 60 cycles on ¼" tape. Used with Nagra, Perfectone, or other battery operated tape recorders. All solid-state, fits in jacket pocket, or outboard on recorder. Also, A.C. powered Type 87, for 14KC sync track, available.
All new, Series 78 and 88 provide ***totally linkless*** Double-System synchronism on location.

TYPE 92B PLAYBACK SYNCHRONIZER FOR SYNCHRONIZATION OF ¼" TAPE IN PLAYBACK WITH SPROCKET DRIVEN FILM

Responsible for tape to film transfer? Check out this addition to the distinguished MTE line of synchronizing equipment. You'll find no other gives you all of the 92B's important benefits:

WIDE RANGE, can correct speed deviations of +20% to −20% from sync speed.

CONTINUOUS DISPLAY OF SYNC CONDITION so user knows exactly whether tape is in sync. Oscilloscope semi-circle pattern moving clockwise indicates tape speed fast, counter-clockwise indicates tape speed slow, semi-circle standing still indicates precise sync speed. In addition, Comparator-driven dial registers % deviation from 7½ or 15 i.p.s. normal speed.

SYNC SIGNAL LEVEL IS INDICATED BY VU METER, an Attenuator provides for boosting weak signals 20 DB. Also a Volt Meter indicates voltage to capstan motor.

HAS MEMORY if sync signal is lost, tape runs at last sync-controlled speed.

ADVANCING OR RETARDING TAPE TO LIP-SYNCHRONISM with picture, when screening, is achieved with a Spinner Knob Framing Control.

VERSATILE REMOTE CONTROLS for operating tape recorder at the Synchronizer are incorporated.

FULLY AUTOMATIC. Choice of automatic speed control for sync transfer work or manual speed control for special effects, pitch change, trimming time spots, etc.

COMPACT. All solid state. Entire 92B unit mounts in 12¼" of rack space, weighs 38 lbs.

COMPATIBLE. Can be used with tape transports including Ampex 350, 351, 354, 300, 400 and others. Uses 60 cycles or 14KC control track supplied by MTE type 87, 88, or any other control track generators, or sync head.

ECONOMICAL. High utility in film studios, music studios, in-plant film production facilities. Solid state reliability eliminates maintenance. Only $1,920.00

Write for 44-page Catalog

M.T.E. MAGNA-TECH ELECTRONIC CO. INC.
630 9TH AVE. N.Y. 36, N.Y.

tional or promotional use. Patrons can select any one, or any number in succession, of 32 individual films in monochrome and color, running about 11 minutes. Manufactured in Italy by Societa Internazionale Fonovisione, the device is distributed in the United States by Don Twomey Associates, Inc., Suite 1512, 230 Fifth Ave., New York.

An all-purpose satellite communications system that would be available to all nations through two or three relay stations "fixed" in space high above the equator has been proposed to the Federal Communications Commission by the Radio Corp. of America. The proposed system would employ synchronous satellite repeaters — space-borne relay orbiting 22,300 miles above the equator, where their speed would match the speed of the Earth's rotation to keep each satellite effectively "fixed" above one point on the Earth's surface. Each satellite would carry relay equipment to receive, amplify and re-transmit signals between ground stations in various parts of the world, providing a high-capacity link for simultaneous telephone, radio and other services. The satellites are pictured as relatively small units, each consisting of a slender cylindrical body 13 ft long, with wide fins bearing solar cells to generate power from sunlight. A dish-shaped antenna at one end is directed constantly toward the center of the Earth. According to the proposal, such a system could be put in effect within the present decade.

Biographical Note

Arthur C. Hardy

Professor Arthur C. Hardy has announced his plans to stop teaching on June 30, 1961, at Massachusetts Institute of Technology where he has taught 41 years. He plans to do writing and consulting work at his home at 15 Kenilworth Rd., Wellesley 81, Mass., and as he says "reserve a little time for some of the things I've always wanted to do but never had time to do."

Dr. Hardy is a Fellow of the SMPTE, and has served on several committees, the Board of Editors and the Board of Governors. He has published more than 40 papers of which 8 appeared in the *Transactions* or the *Journal* of our Society. Dr. Hardy's paper on "Graininess of Photographic Materials Used in the Motion Picture Industry," which appeared in the *Transactions* in 1922, was the forerunner of a number of papers on that subject that came out of the Kodak Research Laboratories.

A world authority on optics and photography, Professor Hardy is perhaps best known in the field of motion pictures for his work in the middle twenties on sound recording on film that was done as a consultant for General Electric Company. His researches in developing the concepts and instrumentation of colorimetry are important as well as the application of these concepts to color reproduction. His book *The Principles of Optics*, authored jointly with F. H. Perrin, is one of the standard references in this field.

Dr. Hardy completed his studies for the B.A. at the University of California in 1917. Almost immediately thereafter, he enlisted in the Photographic Branch of the Signal Corps, was later transferred to the newly formed Air Service, and served in France as the Commanding Officer of the 23rd Photographic Section.

After the war, he completed his Master's work at California and was an instructor at the Massachusetts Institute of Technology until 1920, when he accepted a position in the Research Laboratories of the Eastman Kodak Company. He returned to M.I.T. as an assistant professor in 1922, and in 1933 was made Professor of Optics and Photography.

During World War II, Professor Hardy was Chief of NDRC Section 16.3 (Camouflage) of the OSRD. In that capacity, he inspired and guided researchers in visibility, atmospheric optics, and the influence of color on the perception and recognition of distant objects. In recognition of the value of his war work, he was awarded a Presidential Certificate of Merit.

The St. Lawrence University conferred an honorary Sc.D. upon Professor Hardy in 1938. The next year, he received the Longstreth Medal of The Franklin Institute, which cited his invention of the recording spectrophotometer.

In his recording spectrophotometer, his pioneering use of the null balance principle throughout the optical and electrical systems established an ideal which is rarely attained to the same degree even in instruments designed now, a quarter-century later. The same instrument employed one of the first successful photoelectric servo systems, almost a decade before these systems attained prominence and commanded confidence in war-tested devices.

The commercial version of his spectrophotometer was a remarkably close copy of this prototype, and was not appreciably changed during twenty years, while hundreds were being delivered and used to establish color measurement laboratories throughout the world. The recent redesign by a new generation of engineers left all the basic features of his spectrophotometer unaltered, but used modern components and made concessions to mass-production requirements.

The invention of his spectrophotometer in 1931 coincided with the adoption, by the International Commission on Illumination, of data specifying the standard observer

Looking for a **BUY** in Motion Picture Equipment?

- *Laboratory*
- *Studio Editing*
- *Animation*

- Fish-Schurman Color Heads
- B&H 35 & 16mm Floor Splicers
- S.S. Editing Tables
- Neumade Rewinds
- S.S. Circulation Pumps
- S.S. Sprocket Drives
- B&H 35mm Printers
- Duplex 35mm Printers
- Light Change Boards
- 35mm to 16mm Reduction Printers
- Title Bench With B&H Camera
- 120 fpm Color Processing Machines
- Sound Reduction Printers
- Maurer Optical Recorder
- Mitchell Cameras

Barry Green
509 MADISON AVE.
NEW YORK 22, N. Y.
PLaza 2-7970

THE MARK IV CAMERA CHAIN

EXPERIENCE COUNTS

Marconi's pioneered the use of the 4½ inch Image Orthicon Camera using the tube developed by their associates, the English Electric Valve Company. Marconi's have amassed more 'know-how' on the use of the 4½ inch Image Orthicon than any other manufacturer.

OVER 600 MARCONI IMAGE ORTHICON CAMERA CHAINS HAVE BEEN SOLD THROUGHOUT THE WORLD

BD 863 MARK IV IMAGE ORTHICON CAMERA

EXTREME STABILITY
Novel circuit design and careful choice of components gives such a high degree of stability that operational controls have been removed from the camera.

FIRST CLASS PICTURE QUALITY
The 4½ inch Image Orthicon tube gives a picture quality substantially better than any other type or size.

LIGHT AND COMPACT
By reducing and simplifying the camera electronics its weight has been held below 100 lb. and its size made correspondingly small.

MARCONI®

COMPLETE SOUND AND TELEVISION SYSTEMS

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED
CHELMSFORD · ESSEX · ENGLAND

MARCONI BROADCASTING PRODUCTS ARE DISTRIBUTED IN THE U. S. A. SOLELY BY

AMPEX Video Products Company
REDWOOD CITY · CALIFORNIA

M4D

NOW... for Ektachrome users...

ONE-DAY SERVICE
on 16 mm
COLOR PROCESSING

Licensed by Kodak

EKTACHROME COMMERCIAL 5¢ ft.
EKTACHROME ER FILMS 6¢ ft.

Chemical and sensitometric controls to rigid Kodak standards.

TEXAS INDUSTRIAL FILM COMPANY

TIFCO

2528 NORTH BLVD.
JA 9-4377
HOUSTON

48 HOURS
Camera to Color Print

Let us process your Ektachrome camera film, assemble it, make a
COLOR (11¢)
B & W (6¢)
print with printed edge numbers, then ship to you within 48 hours after receipt of your original.

Write for complete laboratory price list.

and coordinate system for colorimetry. Professor Hardy immediately recognized the usefulness of this information, especially when used in combination with accurate spectrophotometric data. He spent many years devising and teaching methods for facilitating the combined use of these two groups of data, for color measurement in myriad applications.

Early in his program for facilitating the application of spectrophotometry to color measurement, Professor Hardy developed the selected-ordinate method of color calculation, which eliminates almost all of the nearly one hundred multiplications per sample required in other methods. This method employs spectrophotometric data at the closest wavelength intervals in spectrum regions where they are most needed according to the standard-observer data.

The selected-ordinate method and extensive tables to facilitate color computations by both this and the older methods were presented with clear descriptions and examples in the *Handbook of Colorimetry*, prepared under his direction and published in 1936 by The Technology Press. That book also contained a monumental set of large-scale sections of the chromaticity diagram, available nowhere else, for the convenient graphical representation and analysis of the relations among colors. Consequently, the Handbook is still a standard reference work in daily use in hundred of color measurement laboratories throughout the world.

He invented and had built during 1936, as an attachment for his spectrophotometer, an automatic digital integrator that calculated the color specifications for each sample which its spectrophotometric curve was being drawn.

Professor Hardy early recognized that the 1931 recommendations of the International Commission on Illumination necessitated a revision of the report of the 1922 Colorimetry Committee of the Optical Society of America, which had established similar data for use in this country. As Vice-President of the Optical Society, he was instrumental in persuading the late Dr. Loyd A. Jones, a member of the 1922 Committee and his chief during his two years at Kodak, to accept the chairmanship of a committee appointed in 1933 to revise the original Colorimetry Report. Professor Hardy served actively on that committee for almost two decades, until the revised report was published. He played an important role, often lonely and sometimes unpopular, in bringing about the final adoption of the psychophysical and operational basis of the revised report. The report finally appeared as a book, *The Science of Color*, published by the Thomas Y. Crowell Company of New York City in 1953.

Professor Hardy served as President of the Optical Society of America from 1935 to 1937, and as Secretary from 1939 to 1957. During his period of service as Secretary, the memberhsip of the Society almost quadrupled, from 650 to over 2400. In recognition of his distinguished work in optics and related fields, he was awarded the Frederic Ives Medal of the Optical Society of America in 1957.—*Glenn E. Matthews.*

section reports

The Atlanta Section met on April 11 at the Protestant Radio and Television Center with an attendance of 15. Guest speakers were Dr. Ernest Arnold, President of the Center and Carl Degan, Production Manager.

Dr. Arnold welcomed the Section to the Center and explained its work pointing out that it is a nonprofit organization, producing religious programs exclusively for radio and television. It is the largest organization and the only interdenominational one doing this type of production work.

The excellently equipped center has a staff of 31 and handles 1200 taped radio programs each week. In addition to the present ¼-in. sound tape duplication equipment, plans are being made for the installation of facilities for originating and duplicating programs on video tape.

Mr. Degan escorted the group to the Chapel Studio where two films produced by the organization were shown. One, a 27-minute 16mm color film *The Triumphant Tradition* was of interest primarily because it demonstrated the multiple-camera technique used by Mr. Degan in his past experience in producing TV advertising films.

The other example shown was a 9-minute film strip in color with sound. This was an excellent example of the use of contemporary art to illustrate the origin of Christianity.

Following this latter presentation, there was a discussion period and a tour of the facilities of the Center.—John C. Horne, *Secretary-Treasurer*, 404 Page Ave., N.E., Atlanta 7, Ga.

The Atlanta Section met on May 15 at the Georgia Tech Library with an attend-

Erratum

January 1961, New York Section

On p. 56, lines 4–10 of second paragraph:

For: "In commenting on the future of 8mm sound films, he noted that about 8,000,000 8mm projectors are now in use, as against 600,000 16mm projectors, with production running at a rate of 800,000 8mm units versus 50,000 16mm projectors per year."

Read: "In commenting on the future of 8mm sound films, he noted that by the end of 1961 there will probably be between 4 and 5 million 8mm silent projectors in use in the United States as against an estimated figure of 727,000 16mm sound projectors in use in the U.S. as of January 1, 1961. Approximately 700,000 8mm silent units are sold in the United States annually versus 40 to 50,000 16mm sound projectors per year.

Now available!*

1,000 ft. ARRI BLIMP for ARRIFLEX 35

The new 1000 ft. Blimp converts the ARRIFLEX 35 into a full-fledged SOUND STUDIO CAMERA, and brings further versatility to the ARRIFLEX 35 system. It accepts the ARRIFLEX 35 with regular synchronous motor, and utilizes standard Mitchell magazines, which are joined to the camera by means of an adapter, supplied with the Blimp. No alterations are necessary on the ARRIFLEX 35 or the Mitchell Magazine. No tools are needed. It takes but a few minutes to change the ARRIFLEX 35 from hand camera to studio camera or vice versa.

Features:

Modern acoustic damping methods afford extreme sound absorption. Permits use of microphones within 3 ft. of Blimp.
Remote focus drive from 3 positions.
Remote diaphragm adjustment.
Through-the-lens-focusing and viewing.
Matte box with leather bellows adjustable by geared struts.
Large front port permits use of 18mm wide-angle lens.
Adapter available to use anamorphic lenses.
Built-in filter holder for 3x3" filter.
Large Control windows for distance scale, diaphragm scale, footage counter and tachometer.
Wired for buckle switch which can be built into existing cameras and is factory supplied with camera if bought with Blimp.
ARRI-Precision Engineered for a lifetime of trouble-free service.

$3,995.00 FOB N.Y.

*for SALE, RENT, LEASE

Frank C. Zucker
Camera Equipment Co., Inc.
315 West 43rd St. New York 36, N. Y.
JUdson 6-1420

Behrend Cine Corp.
(formerly Television Equipment Co.)
161 E. Grand Ave. Chicago 11, Ill.
Michigan 2-2281

or direct from

ARRIFLEX CORPORATION OF AMERICA
257 PARK AVENUE SOUTH, NEW YORK 10, N. Y.

Professional Services

TIME LAPSE — HIGH SPEED
SCIENCE MOTION PICTURES
Bacteriology, chemistry, scientific special effects applied to motion pictures and TV
Consultation and production since 1929
THE BERGMAN ASSOCIATES
732 Eastern Parkway, Brooklyn 13, N. Y.
SLocum 6-0434

SAVE 25–50% ON PRINT COSTS
Users of Permatilm Protection and Perma-New Scratch Removal show savings ranging from 25% to 50% and more by lengthening the life of their prints. A money-back test will convince you.
PERMAFILM INCORPORATED
723 7th Ave.-New York 19-CI 6-0130
PERMAFILM INC. OF CALIFORNIA
7264 Melrose Avenue
Hollywood Webster 3-8245

IN THE SOUTHWEST
For Equipment and Stage Rental
Technical and Creative Personnel
Complete 16mm and 35mm
Laboratory and Producer Services
It's BIG "D" FILM LABORATORY, Inc.
4215 Gaston Plaza, Dallas 10, Texas.
TAylor 7-5411 I.A.T.S.E.

PHOTOGRAPHIC INSTRUMENTATION
Specializing in
HIGH-SPEED
Motion-Picture Photography
Photographic Analysis Company
100 Rock Hill Rd., Clifton, N. J.
Phone: Prescott 9-4100

8MM SOUND STRIPING
CINECRAFTERS
DEPT. S, 219–44 JAMAICA AVENUE
QUEENS VILLAGE, N.Y.

SUPPLIERS
PHOTOGRAPHIC CHEMICALS
and
Consultants in Photographic Chemistry
L. B. Russell Chemicals, Inc.
14-33 Thirty-First Avenue
Long Island City 6, New York
RAvenswood 1-8900

CRITERION
FILM LABORATORIES, INC.
Complete laboratory facilities for 16 & 35mm black-and-white and color
33 West 60th St., New York 23, N. Y.
Phone: COlumbus 5-2180

FILM PRODUCTION EQUIP.
SALES
LEASING
SERVICE
World's largest source—practically every need for producing, processing, recording, editing motion picture films
S.O.S. Photo-Cine-Optics, Inc.
formerly SOS Cinema Supply Corp.
New York City: 602 West 52nd Street, PLaza 7-0440
Hollywood, Calif.: 6331 Hollywood Blvd., HO 7-2124

ELLIS W. D'ARCY & ASSOCIATES
Consulting and Development Engineers
8mm Magnetic Sound Printers
Motion-Picture Projection
Magnetic Recording and Reproduction
Box 1103, Ogden Dunes, Gary, Ind.
Phone: Twin Oaks 5-4201

ALL 16mm PRODUCERS SERVICES
Equip. Rentals • Technical Crews
40 × 70 Sound Stage
16mm LABORATORY FACILITIES
Exclusive TRIAD Color Control
Additive Color Print Process, Plus B & W
SOUTHWEST FILM CENTER
3024 Ft. Worth Ave., Dallas 11, Texas

16mm SOUND
Modern Sound Recording Studio
Narration Recording
Magnetic & Optical Rerecording & Mixes
Music-Effects Library
FISCHER PHOTOGRAPHIC LABORATORY, INC.
6555 North Ave., Oak Park, Ill., EUclid 6-6603

• SYNCHRONOUS MAGNETIC FILM RECORDER/REPRODUCER
• MAGNETIC TAPE RECORDERS
• NEW—THE *portable* MINITAPE *synchronous* 13 lb. battery operated magnetic tape recorder for field recording.
THE STANCIL-HOFFMAN CORP.
845 N. Highland, Hollywood 28
Dept. S HO 4-7461

RENT
16mm, 35mm, 70mm
Motion Picture Cameras
High Speed Cameras
Special Cameras
Lenses
Lights
Processing Equipment
Editing Equipment
GORDON ENTERPRISES
5362 N. Cahuenga, North Hollywood, Calif.

16mm CENTRAL PROCESSING SERVICE
Anscochrome Ektachrome ER
Reversal—Negative—Positive
Printing—Recording—Rental—Editing
WESTERN CINE SERVICE, INC.
312 S. Pearl Ave., Denver 9, Colo.
Sherman 4-1017

TUFF COAT
Cleans, kills static, lubricates and invisibly coats and protects all types of film against scratches and abrasions. SAFE, easy to use. NO carbon tet. Special type available for magstripe and video tape. Write for brochure "S"
NICHOLSON PRODUCTS COMPANY
3403 Cahuenga Blvd. Los Angeles 28, Calif.

PRECISION OPTICAL ETCHING
Reticles-Viewfinders-Scales-Ground Glass & Opaque Reticles
For TV-Motion Picture-Optical Instrument Engineers
E. YOUNGLING
24 Collins Rd., Glen Cove, L. I., N. Y.
ORiole 6-7774

ance of 14. Marshall Cooksey, Research Engineer, Engineering Experiment Station, Georgia Institute of Technology, was the guest speaker. He discussed "Problems in Optical Instrumentation—Rocket and Missile Photography."

Mr. Cooksey gave a brief outline of the purpose and function of the Georgia Tech Research Experiment Station. In 1960 over $5 million was spent on research at the Experiment Station. The projects were classified in three categories: (1) State sponsored; (2) private industry; (3) Federal (including research and development of military equipment).

The principle of the intermittent motion-picture camera operating at maximum speed of 400 frames/sec was pictorially compared to the rotating compensating prism camera operating in the range of 2,500 frames up to 4,000 frames/sec.

A number of film clips photographed with the Wollensak Fastax high-speed camera were shown in conjunction with a demonstration of various applications of the camera.—John C. Horne, *Secretary-Treasurer*, 404 Page St., N.E., Atlanta 7, Ga.

Dr. Walter P. Siegmund was guest speaker at the April 12 meeting of the **Boston Section.** Fifty-nine persons attended the meeting at the WBZ-TV Studios to hear Dr. Siegmund discuss, "Fiber Optics."

Dr. Siegmund presented a very interesting program, well illustrated with slides and several examples of special applications of fiber optics. A lively post-meeting discussion indicated intense interest.

Twenty members of the Optical Society of America were present at this meeting.

Dr. Siegmund and Mr. Fiddes of the American Optical Co., were guests of the Section at dinner earlier in the evening.—Lester E. Bernd, *Secretary-Treasurer*, Information Technology Labs., 10 Maguire Rd., Lexington, Mass.

The Canadian Section met on April 5 at the National Film Board Auditorium in Montreal with a large attendance.

The meeting began with the showing of a selected film which was followed by the presentation of a paper entitled "A Versatile Animation Camera and Stand," by Douglas M. Roberts.

A coffee break sponsored by Alex L. Clark Ltd., of Toronto, followed Mr. Robert's discussion.

Vice-President Edward Schmidt of Reeves Soundcraft, Danbury, Conn., presented a paper on the "History and Developments of Magnetic Film Striping in the U.S."

At the close of the meeting, interested persons were invited to view the equipment described by Mr. Roberts.—Harold Green, *Secretary-Treasurer*, Park Photo Supply Co., 77 Craig St. West, Montreal, P.Q.

Vice-President William Hedden of Calvin Productions, Inc., addressed the April 18 meeting of the **Chicago Section** at the St. Clair Hotel. Eighty persons were present to hear Mr. Hedden's discussion of "16mm Camera and Release Print Stocks."

The speaker's talk dealt with the use of various types of film for use in 16mm cameras and release prints. A 16mm film was shown which compared printing results,

all taken from a Commercial Ektachrome original, on Kodachrome Reversal print stock, color negative-positive print stock, and black-and-white Ortho, Pan, and TV release film.

A second comparison was shown illustrating results on 5269 Duplicating stock from a Commercial Ektachrome original and Kodachrome Type II original.

A third film illustrated the effects, timing and color corrections on color printing. A fourth film was shown which compared various black-and-white prints including reversal as well as negative-positive printing. The audience was thus able to judge the merits and effectiveness of the various types of printing stocks and techniques used.

During the afternoon, a Board of Managers' meeting was held at the Behrend Cine Corp. offices followed by dinner at Tracey's Restaurant.—Philip E. Smith, *Secretary-Treasurer*, Kodak Processing Lab., 1712 Prairie Ave., Chicago 16.

The Chicago Section met on May 16 at the St. Clair Hotel with an attendance of 80. Dr. Walter P. Siegmund, Assistant Director of Research, American Optical Co., was the guest speaker. His subject was "Fiber Optics."

During his discussion of the theory of transmission of light by glass fibers, Dr. Siegmund used slides to illustrate the practical applications of fiber optics in the transmission of light and the modification, dissection, scrambling and reconstruction of images transmitted through a fiber optics system. A few of the many applications of fiber optics are found in coding work and medical photography.

Prior to the meeting, there was a brief Board of Managers' conference, followed by dinner. A coffee break was held following Dr. Siegmund's presentation.—Philip E. Smith, *Secretary-Treasurer*, Kodak Processing Lab., 1712 Prairie Ave., Chicago 16.

The Hollywood Section met on May 16 at the Metro-Goldwyn-Mayer Theatre with an attendance of 285. Guest speakers were Walter Beyer, Cordova, Inc.; Eric House, Technicolor Corp.; G. M. Sprague, MGM Sound Dept.; and John Waner, Eastman Kodak Co.

MGM Studios generously provided a meeting place and facilities for the meeting which was opened with a 16mm color documentary film prepared by North American Aviation Co. The film showed the X15 in manufacture, information on studies and research necessary both before and during actual flight.

Mr. Beyer described a new cartridge type projector and film system that facilitates the showing of a vast amount of picture information contained in a relatively small reel. Other applications such as educational and training films, double-frame projection and 3-D projection were also demonstrated and discussed.

Mr. House described the methods used by Technicolor for preparation of 8mm magnetic-sound release prints made from 35mm Eastman color negative and 16mm Ektachrome source material.

Mr. Sprague described the transfer from a magnetic master to quadruple rows of magnetic striping in the preparation and

THE BEST WAYS TO IMPROVE PRINT QUALITY

Peerless Reconditioning

for scratched, shrunken and buckled originals and prints

Peerless Treatments

for all pre-print material, and release prints

PEERLESS
FILM PROCESSING CORPORATION
165 WEST 46th STREET, NEW YORK 36, NEW YORK
959 SEWARD STREET, HOLLYWOOD 38, CALIF.

S.O.S. EDIOLA PRO-35

Professional Precision at a Price!

Available with Optical/Magnetic or Combination Sound Reader

- Large Screen: $4^3/_8$" x $6^1/_{16}$"
- Brilliant Picture Image
- 75 watt lamp; fan cooled
- Velvet action Nylon Rollers
- Film travels Left to Right
- Simplified Framing and Focusing
- 4-sided Prismatic Shutter
- Lightweight, compact design

A 35mm ACTION VIEWER designed for easy editing. Precision optics assure bright pictures in sharp focus whether film is moving or stopped. Film protected from overheating or burning. No intermittent or oscillating parts. Free turning sprocket guards against film damage

SPECIAL INTRODUCTORY OFFER!

S.O.S. EDIOLA PRO-35..... $295

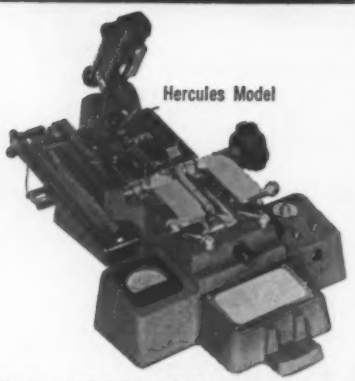
S.O.S. Pro-35, Optical Sound Reader and Base..... $495

S.O.S. PHOTO-CINE-OPTICS, INC.

formerly S. O. S. CINEMA SUPPLY CORP.

602 WEST 52nd ST., NEW YORK 19, N. Y. • *Phone:* PLaza 7-0440 • *Telegram:* QHP, N.Y.
Western Branch: 6331 Hollywood Boulevard, Hollywood 28, California • HOllywood 7-2124

NEW
INTERMIX
PRESTO-SPLICER
HANDLES EVERY JOB

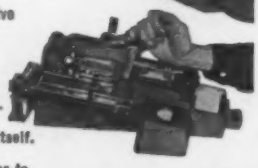


Newly modified Presto-Splicer butt-welds motion picture film, microfilm, acetate, mylar, Polyester, safety-base, paper . . . or any other kind of tape or film . . . AND INTERMIXES ANY OF THESE MATERIALS making a failure-proof, invisible weld that is literally the strongest part of the tape. Every splice you make will be a cleaner splice . . . a stronger splice . . . a PERMANENT splice, with

PRESTO-SPLICER

Slide handle toward you as far as it will go. This brings the special Mylar* tape with thermal setting adhesive into position.

Splice in the usual manner. Heat sets the adhesive but does not disarrange the molecular structure of the tape. The bond is permanent, stronger than the film itself.



Use the trimmer to remove the surplus tape. The entire procedure is so simple, so positive, that no special training is needed for your existing personnel.

*T.M. E. I. duPont de Nemours & Co.

For further information, write

PRESTOSEAL MANUFACTURING CORP.
37-27 33rd Street
Long Island City 1, N. Y.

Export: Reeves Equipment Corp.
P. O. Box 171, Pelham, N. Y.

making of 8mm magnetic-sound release prints.

Mr. Waner discussed the system used by Eastman Kodak Co. to provide 8mm Sonotrack. Quality control data from operating experience were reviewed to indicate reasonable production control for the guidance of laboratories that may wish to design similar striping systems.—John Kiel, *Secretary-Treasurer*, Photo-Sonics, Inc., 820 South Mariposa St., Burbank, Calif.

The Nashville Section met on May 20 at the Studios of WLAC-TV with an attendance of 16 members and guests. Guest speaker Jack West, Manager of the Central Division of General Film Laboratories, discussed "Video Tape-to-Film Transfers."

Mr. West's talk was concerned with the demand which has arisen for video tape-to-film transfer and the way in which his laboratory is accomplishing it. His discussion was followed by the presentation of several examples of 16mm transfers, the playback of a program on WLAC-TV's video-tape facilities and its corresponding film transfer for direct comparison.

Coffee was served, courtesy of WLAC-TV.—H. R. Briscoe, *Secretary-Treasurer*, 403 Signal View, Chattanooga 5, Tenn.

Executive Vice-President Glen G. Magnuson of the Kalvar Corp. was guest speaker at the May 17 meeting of the **New York Section.** One hundred ten persons attended the meeting at the World Affairs Center Auditorium to hear Mr. Magnuson discuss "The Kalvar Story."

The speaker presented a new system of photography which does not require chemical processing. The system of Kalvar entails exposure of the film to light and subsequent heating to produce a developed image. The material may be safely handled in daylight without deterioration. Kalvar is unique in that the opaque area of the film is composed of light-scattering centers rather than the light-absorbing grains of conventional photographic films. Although the opaque area appears white to the eye, it projects black on the screen.

A demonstration was made with a simple engineering drawing negative placed in contact with a sheet of Kalvar film and exposed and developed in a 300-w slide projector. The entire process took about three seconds to complete and the developed image was then projected. A further demonstration proved that the film was inert to the action of water, alcohol and carbonated beverages. A simple cleaning with a dry cloth returned the product to its original state.

Mr. Magnuson stated that the United States Bureau of Standards has assigned a shelf life of 5 years to this product. He pointed out, however, that a much longer period of life is probably more realistic. Because insufficient time has elapsed since the inception of this process, longer official shelf life times could not be assigned.

Many applications of the product were discussed including data recording by the Armed Forces, and professional motion pictures. A new company owned jointly by Kalvar and MGM has been formed to develop motion-picture techniques.

Mr. Magnuson's talk did not elaborate on technical aspects, but a question-and-answer period provoked interest along these lines. He did mention, however, that currently they are using Mylar base and that other bases have been tried on an experimental basis. He promised to send technical manuals to those members requesting them.—William H. Metzger, *Chairman*, Ansco, 405 Lexington Ave., New York, N.Y.

Allen L. Sorem of the Applied Photography Div., Research Laboratories, Eastman Kodak Co., addressed the April 27 meeting of the **Rochester Section.** His subject was "The Potential Role of Photography in Space." Fifty-one persons attended the meeting at Dryden Theatre.

Mr. Sorem traced man's attempt to obtain aerial photographs from various carriers such as the pigeon, balloon, airplane and rocket. Examples of the results obtained by the use of each type of carrier were shown in slide form along with the cost on a per square mile photographed basis.

Recent developments in films enabling the user to make detailed ground photographs from high altitudes were shown as examples of improvements in film definition and resolution capabilities.

According to Mr. Sorem, "Photography has been made so easy that many people take it for granted. However," he pointed out, "photographic quality of a level that would warrant an attempt to take pictures from space vehicles will only be obtained by the most careful engineering of the complete photographic system."

The speaker's discussion showed how photographic results may be predicted in advance from laboratory data and aerial tests.

The film *This is Color* preceded the meeting.

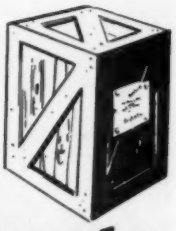
A group of members met at the Treadway Inn before the meeting where Mr. Sorem was our guest at dinner.—D. Lyle Conway, *Secretary-Treasurer*, Maple Hill Farm, R.D.2, West Monroe, N.Y.

The Washington Section met on April 17 at the National Academy of Sciences Auditorium with an attendance of 35. Guest speakers were: Arthur L. Foster, Chief, Film Processing Laboratory, U.S. Dept. of Agriculture, whose subject was "Quality Control in Film Processing"; and John H. Roe, Manager, TV Camera Engineering, Broadcast and Television Equipment Div., RCA, who discussed "New Camera Tubes and Cameras."

Mr. Foster's paper was based on the SMPTE book, "Control Techniques in Film Processing." The set of slides accompanying the lecture contributed to the better understanding of the subject. The Section expressed its appreciation to Mr. Foster and Walter E. Shea of Eastman Kodak Co., who handled the projection for this part of the program.

From Mr. Roe's well presented paper and the clarifying assistance of pertinent slides, the Section gained a good understanding of various models of image-orthicon picture tubes and RCA's model TK-12 television camera.

Informal discussion over refreshments furnished by John Waller of Bell & Howell Co., followed the formal presentations.—David E. Strom, *Secretary-Treasurer*, 1002 By-Pass Rd., Williamsburg, Va.



new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

Application of the "stimulated emission" principle of the maser to direct amplification of sound waves was demonstrated at General Electric Research Laboratory for the first time, according to an announcement issued May 17. Source of power for the amplification of sound waves (phonons) is microwave radio energy. The effects (called the phonon maser effect) is accomplished by stimulated emission of energy by atoms as they move from a higher to a lower energy level. The effect has been demonstrated with short pulses of very high frequency (9.3 kilomegacycles) sound in a ruby crystal which consists of alumina (Al_2O_3) with chromium ions as an impurity. When it is subjected to a magnetic field, the electrons on the chromium ions, acting as small magnets, tend to line up with the field. Each electron has four characteristic energy levels, corresponding to how closely it lines up with the applied field. Most of the electrons are in the lowest energy level, but can move to higher energy levels by absorbing energy at a certain resonant frequency, which is set by the magnetic field strength and the characteristics of the electrons in the crystal. The reverse transition, from a high to a low energy level, can be made by emission of energy at the resonant frequency.

From Coon Peak in the Oquirrh Mountains in Utah to the top of Albion Peak in Idaho, a single microwave beam, sent from a 10-ft, dish-shaped parabola antenna, traverses the Great Salt Lake, crosses the salt flats at the north and slices through a 5400-ft mountain pass to reach the receiving point on Mt. Albion, 7000 ft above sea level. From Albion Peak, a connecting microwave link flashes the signal to the transmitter site of Station KID-TV, Idaho Falls. The system, designed by RCA, has been announced as the "longest line-of-sight microwave transmission ever accomplished for television relay." (Since the microwave signal requires an unobstructed line-of-sight, relay stations ordinarily are located no more than 25 to 30 miles apart.) The equipment used in the system is RCA's TVM-1B microwave relay equipment.

ALLEN

Model 200
16 MM negative-positive

FILM PROCESSOR

FOR ECONOMICAL AUTOMATIC PROCESSING

Entirely self contained with every accessory . . .
Allen processing machines have all the necessary equipment for convenience, easy maintenance, automatic operation. No need to add expensive accessories.

Fully automatic with variable speed drive . . .
Requires no attendance other than changing reels. Continuous variable speed drive permits accurate speed adjustments for various emulsions.

Complete plumbing system with tank drains . . .
A unique and exclusive plumbing system provides individual tank draining and back flushing with fresh water. Reduces maintenance to a minimum.

Compressed air squeegee and wash spray bar . . .
Built-in compressor provides filtered air to render film evenly damp dry before entering dry box. Wash tank overflow allows adjustment of spray bar wash.

PRICED COMPLETE AT ONLY $1995.

16/35 combination and microfilm models available

ALLEN

for complete information write to:

PRODUCTS INC.

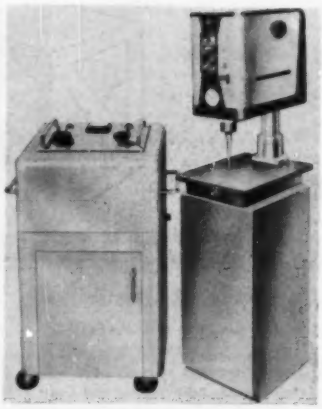
Factory Lane, Milford, Connecticut

Distributed by: S.O.S. PHOTO-CINE-OPTICS, INC.
602 WEST 52nd ST., NEW YORK 19, N.Y.

The Acmade Automatic film splicer is available from Florman & Babb, Inc., 68 W. 45 St., New York 36, distributors for the English firm. Used for making butt splices, it applies Mylar perforated tape on 35mm and 16mm film as well as on all film bases, including Cronar. To make a splice, the operator presses a button after the film has been registered on precision pins and the splicing arm moved over until it is in place above the film. The pushbutton operation simultaneously cuts the adhesive and applies it to the film. The cutting arm, used to cut both sides of the film simultaneously after the film has been registered on pins in the horizontal channel, also operates automatically when the pushbutton is pressed. When the film is cut, the cutting arm can be moved to one side so that the splicing operation can be completed. Both arms are precision registered to exact specifications. The splicer is priced at $295.

HFC Repair Splicers produced by Hollywood Film Co., 956 Seward St., Hollywood 28, employ Mylar tape with an adhesive back to splice or repair film for general purposes or for use in processing machines. The tape is applied onto the film and a solenoid action perforates the tape in alignment with the film perforation while simultaneously shearing both sides of the film. The 35mm models are available with negative or positive perforations and the area covered is one frame. On the 16mm model two frames are covered. Models for 65mm negative, 70mm theater release film, or military specifications #1 or #2 are available on special order.

A newly developed table-model splicer capable of being used for darkroom splicing of raw stock and preparation of A&B roll printing has been announced by Harwald Co., 1245 Chicago Ave., Evanston, Ill. The splicer features an automatic pre-set scraper said to require only three seconds of preparation for an accurate (reported within 1/10,000-in.) splice, with the entire splicing process completed within nine seconds. Available in three models, Model A, priced at $99.50, has its registration pins in the conventional position at the rear of the splicing plate; Model B, priced at $175, has registration pins in the center of the plate so that 16mm and 8mm splices can be made in any emulsion position without "criss-crossing," and Model C, priced at $175, for 35mm film.

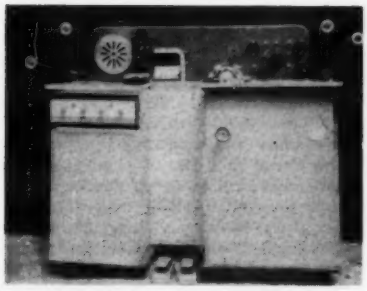


The Zephyr 300 Ultra Sonic Sealer produced by Ultra Sonic Seal, Inc., a Subsidiary of Kleer-Vu Industries, Inc., 76 Madison Ave., New York 16, depends on ultrasonic energy for its sealing and welding operations. Used on Mylar and Cronar as well as other types of film and other materials, it is said to be suitable also for splicing video tape and sealing leaders to coated surfaces of magnetic recording tape. In operation, according to the announcement, the welding device, or operating tool, moves at the rate of 20,000 vibrations per second, and the splicing or welding takes place because of the release of kinetic energy within the materials to be joined. The sealer consists of two separate units. The driver unit, which weighs approximately 200 lb, houses a 25-kc power generator and associated control panel. The head section contains an air-cooled transducer and the operating tool and is mounted on an adjustable base which can be used as an anvil. This section weighs about 85 lb and can be operated from a 115-v a-c line. When film or other material to be spliced or bonded is placed in contact with the operating tool, an imperceptible vertical motion generates heat internally between the sandwiched layers of material creating a molecular bond, while leaving the outer surfaces cool. The machine has been tested on film and other materials ranging in thickness from ¼ mil to 100 mil at speeds up to 100 ft/min.

The HFC Sound Speed Attachment (SSA-1) for synchronizers, announced by Hollywood Film Co., 956 Seward St., Hollywood 38, is designed to aid in editing and dubbing operations by driving the sychronizer at sound speed (36 ft/min in 16mm and 90 ft/min in 35mm). The attachment consists of a geared motor, capacitor, coupling and a 3-way toggle switch. It can be attached to any synchronizer. It is priced at $192.

Membership Certificates (Active and Associate members only). Attractive hand-engrossed certificates, suitable for framing for display in offices or homes, may be obtained by writing to Society headquarters, at 55 West 42d St., New York 36, Price: $2.50.

rewinders
picture and sound editors
video tape
sound readers
synchronizers
crab dolly
first IN EDITING EQUIPMENT
From the time motion pictures "learned to talk" Moviola has earned acceptance as the word for professional film editing equipment. Moviola is keeping pace with the changing needs of the Motion Picture Industry with new devices such as:
• Crab Dolly for improved Motion Picture and TV Camera mobility
• 70 mm Viewer for the Photo Instrumentation field
Moviola MANUFACTURING CO.
1451 GORDON STREET • HOLLYWOOD • CALIFORNIA • HO. 7-3178



A new 16mm editor in the Editors Desk series has been announced by Palmer Editors, 73–40 Vleigh Place, Flushing 67, N. Y. The machine has two channels, one for picture and one for sprocketed magnetic film. The soundhead is directly over the picture aperture for easy editing. The takeup reels are power driven, forward and reverse. Instant stopping is provided and a clutch release allows for hand operation. A standard type of synchronizer is provided which indicates frame and footage. The table measures 48 by 18 in.

Improvements on the Model "U" Inspect-O-Film machine for inspecting, editing and cleaning motion-picture film and the development of the Inspect-O-Film Junior (Junior Consolette Model 61) have been announced by Harwald Co., 1245 Chicago Ave., Evanston, Ill. Improvements on the Model "U" machine include a new speed control and braking system which can be electrically adjusted. The work surface (546 sq in.) has been arranged to provide overall illumination with built-in adjustable shade.

The new Junior model is 48 in. long and 22 in. deep. Designed especially f r use in small film centers and libraries, the machine is reported to have a 2000-ft reel capacity, maximum inspection speed of 650 ft/min and 2000 ft/min rewind speed with automatic stop. The machine is designed so that splices can be made without unthreading the film. It is priced at under $2000.

A new air sqeegee, the Model HB-2, designed for use on any 16mm or 35mm continuous film-processing machine, has been announced by Gryphon Corp., P.O. Box 854, Burbank, Calif. Using a combined Venturi-airfoil principle, the unit is designed to remove all surface liquid from the film as it passes through the sqeegee on an air cushion, thus avoiding contacting with metal parts. The sqeegee is also designed to open automatically for passage of all commonly used film splices. The machine is made of stainless steeel and is constructed for easy adjustment to any processing machine. It has been tested by the manufacturer at speeds in excess of 200 ft/min. It is priced at $100.

Availability of a U/L approved "SCR" Dimmer in 4, 5, and 6 kw capacity has been announced by Kliegl Bros., 321 W. 50 St., New York 19. Designed for flexibility, the dimmer can be operated remotely, or can be installed as part of a control console or incorporated in a lighting cross-connect circuit selected system. The dimmer is a plug-in type and each dimmer incorporates two silicon controlled rectifiers in a back-to-back circuit to provide a symmetrical alternating current output to the lighting load it controls. The control voltage does not exceed 28 v d-c at 12 ma. Full line voltage to the lights is carried and controlled solely by the rectifiers. Each unit is equipped with a circuit breaker and a pilot light which indicates the operational state of the unit.

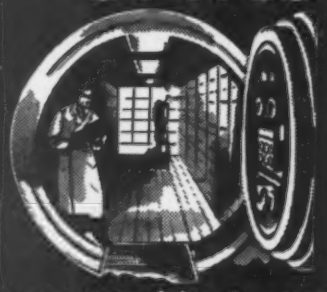
A new series of U/L approved dimmers with silicon-controlled rectifiers has been announced by Century Lighting. First installation was in the Yale University Drama School Auditorium. Presently available is a plug-in type in sizes up to 6000 w. Equipment for higher wattages is expected to be available soon. The new system, as well as other lighting control systems and equipments, is described in the Century Data Book, available without charge from Century Lighting, 521 W. 43 St., New York.

A new lens bench for rapid electronic testing of photographic lenses has been introduced by Eastman Kodak Co. The machine compares the amount of energy concentrated by the lens in a circle of very small diameter with the total amount of light in the image to determine if the lens under test is up to standard. The total energy and the energy passing through a small circular aperture are shown on a cathode-ray tube for comparison. A series of the test apertures drilled in a spiral on a rotating plate scans the image from side to side to determine the uniformity of the light-concentrating power of the lens being tested. Modifications of the testing machine make it possible to use the electronic signal that appears on the cathode-ray tube—the difference between total energy and energy passed through the scanning disc—for electronic positioning of the lens in its mount. The bench was described by William T. Sherwood at the recent meeting of the Society of Photographic Scientists and Engineers.

A 90mm *f*/1.0 lens has been designed by Bausch & Lomb especially for use in the Fluoricon x-ray image intensifier developed by General Electric. This fluoroscopic

send for this NEW BROCHURE SP-52
on
FILM SPROCKETS
STOCK ITEMS
(IMMEDIATE DELIVERY)
for 16 mm., 35 mm. and 70 mm. films. Like all LaVezzi products these sprockets are of highest quality, assuring smooth operation . . . and long, trouble-free life.
Film Sprockets
by
LaVezzi
SPECIALISTS SINCE 1908
Also
SPROCKETS PRODUCED
TO YOUR SPECIFICATIONS
in all practical materials, all sizes and types, small or large quantities, for all applications. For information or quotes
write, wire, or phone
SPROCKET
SPECIALISTS
SINCE 1908
LaVezzi MACHINE WORKS
4635 WEST LAKE ST., CHICAGO, ILLINOIS
Telephone ES 8-1636

Repair-Testing & Modification
of OPTICS



From World's Largest
"LENS BANK"

WHATEVER your PHOTO-OPTICAL problems — TESTING — REPAIR — MODIFICATION — COATING — COLLIMATION, ETC. — B & J can provide you "OFF-THE-SHELF" ACTION!

ALL WORK UNCONDITIONALLY GUARANTEED.

RESEARCH OPTICAL ASSEMBLY LAB solves your special custom lens problem! Our precision grinding, rigid testing, custom mounting and lens coating are speedily done by expert craftsmen to meet the specific requirements of such companies as Ford, RCA, GE, AEC.

OUR NEW PHOTO OPTICS 63rd ANNUAL CATALOG—WRITE FOR FREE COPY TO BURKE & JAMES, INC., AT THE ADDRESS SHOWN BELOW.

PHOTO
Equipment

Geared to
Industrial &
Scientific Uses

FREE 64th Annual Catalog

- CAMERAS, *Enlarging, Copying, Reducing, Professional, Special.*
- BACKS, *World's Greatest Selection.*
- DEVELOPING *Equipment.*
- DRYERS
- ENLARGERS, *Solar.*
- GRAPHIC ARTS *Equipment.*
- LENSES, *World's Largest Variety. In Stock!*
- LIGHTING, *Strobe, Hi-Pro.*
- PRINTERS
- PROCESSING
- SLIDE *Equip.*
- TANKS
- CINE-MICROFILM
- INSTRUMENTATION

145 illustrated pages of the newest and finest "Photo Tools and Techniques" ever assembled in one book! Write for yours . . .

FINE PHOTO EQUIPMENT SINCE 1897

BURKE & JAMES, INC
321 S. Wabash Chicago 4, Illinois

system, used for medical research and diagnosis, uses mirror magnification, closed-circuit TV and motion pictures to display x-ray images. Functioning as a relay lens system, the new lens picks up the image from a phosphor screen rather than directly from the x-rays, and is designed to photograph in the region of 0.550-micron light. The five-element design of the optical system is said to produce increased light transmission and uniformity of screen illumination. The lens is also said to have a high degree of aberrational correction without resorting to aspheric surfaces. Detailed information is available from the Photographic and Optics Sales Dept., Bausch & Lomb Inc., Rochester 2, N.Y.

A vidicon TV film camera (Model V-900), designed for maximum horizontal resolution, gray-scale response and linearity, has been announced by the Vicon Division of the American Microwave and Television Corp., 1369 Industrial Rd., San Carlos, Calif. Introduced at the NAB Convention held in May in Washington, D.C., the camera is said to provide the broadcaster with film reproduction of 800-line horizontal resolution in the center and 600 lines in the corners. Response is reported at 50% at 800 lines and 75% at 600 lines. The design incorporates electron optics, which produce an extremely small, high-density electron beam, to eliminate the need for aperture correction. All voltages, including camera filaments are regulated electronically. A cascode input stage and special low noise resisters are incorporated to achieve a high signal-to-noise ratio.

An image orthicon camera, the V-600, is a product of Foto-Video Electronics, Inc., 36 Commerce Rd., Cedar Grove, N.J. Designed for live-image or closed-circuit monochrome use at 600-line minimum resolution, the camera weighs 25 lb and occupies 25 cu ft of space. It can be fitted with conventional studio lenses or with a variety of Zoomar lenses. Designed for high sensitivity, the camera is said to provide good fidelity at light levels of less than 1ft-c. Modular in construction with wing side doors and hinged top, a transistorized preamplifier plug-in module uses a high-gain, double cascode circuit arrangement to assure maximum freedom from noise. Other features include an individual high peaker in the camera head to produce high-frequency response with high signal-to-noise ratio; built-in adjustable independent aperture and phase corrector; and an all-transistorized constant-current regulator for focusing.

An electronic device called AMTEC (Ampex Time Element Compensator), designed to provide instantaneous and automatic line-by-line compensation of timing errors in the composite video signal, has been announced by Ampex Video Products Co., Box 3000, Redwood City, Calif. An engineering model of the device, originally developed at CBS, was introduced at the Society's 1960 Spring Convention in Los Angeles. Further developmental work has been conducted at Ampex laboratories and the production model, demonstrated at the NAB Convention held in Washington, D.C., in May, has been fully transistorized. With its fully contained power supply the device occupies only 5¼ in. of rack space. In operation it samples the timing accuracy of the recorder's playback signal at the rate of once each horizontal interval. The timing error (if present) is detected and compensation completed in time to correct each horizontal sync pulse and its accompanying line of picture information. The device has been described as an "automatic watchman" to prevent picture distortions such as skewing, scalloping and horizontal line displacement, from reaching the viewing screen.

A closed-circuit TV tape recorder, designed specifically for nonbroadcast applications (educational, military, industrial, etc.), has been announced by Ampex Video Products Co. 2755 Bay Road, Redwood City, Calif. The new Recorder, called the VR-8000, incorporates a single record/reproduce video-head helical scan recording technique specifically designed for closed-circuit application. The new recorder is said to provide all the detail and gray scale tone values the TV camera is capable of picking up. A video erase unit incorporated in the machine covers the full 2-in. width of the tape. A separate audio erase head is included. The 7½-in./sec tape speed permits the recording of two hours of material on a standard 12½-in. reel of 2-in. tape. The machine weighs approximately 500 lb and is self-contained in a cabinet 24 in. deep, 56 in. high, and 42 in. wide and occupies 7 sq ft of floor space. It operates from 117 v nominal a-c, 60-cycle at 15 amp. Also available are 220-v, 50-cycle versions. The basic price is $20,400.

A miniaturized color conversion unit for Ampex VR-1000 Videotape Recorders has been announced by Ampex Video Products Co., Box 3000, Redwood City, Calif. Trade-marked as the Colorter system, it occupies only 4¼ in. of rack space. According to the announcement, the device eliminates the complex conventional signal proc-

essing of decode–encode systems or heterodyning systems. The device is described as a direct color recovery system employing precise time-base compensation of the tape signal so that the resultant signal is within the required stability limits. In operation it is said to accomplish line-by-line compensation of timing errors in the composite color signal by sampling burst phase of the signal each horizontal interval, with respect to the external 3.58-mc signal. The instantaneous phase difference between the sampled and reference signals is converted to a proportional voltage which adjusts the delay time of a voltage controlled delay line in the video signal path. The unit was demonstrated at the NAB Convention held in Washington, D.C., in May.

A dynamic, nondirectional, voice-range microphone, the E.V Model 652, designed for use in small stations or studios with an acoustic problem that can be alleviated by use of a close microphone, has been announced by Electro-Voice, Inc., Buchanan, Mich. A 24-in. "neck" of semi-rigid ¼-in. tubing permits mobility of the microphone in relation to the speaker or performer. Supplied with two transparent baffles to allow accentuation of the presence range, the smaller baffle is used for a 3-db boost and the larger for a 6-db boost at 5000 cycles/sec. Used without a baffle, the microphone is said to provide smooth response from 80 to 8000 cycles.

A motion-picture projection system called Strato-Cinema developed especially for showing entertainment films to passengers on airliners, has been tested on a TWA jet New York-Miami flight and will soon be installed on TWA jet transcontinental and transatlantic flights for the entertainment of first class passengers. Installation kits will be manufactured exclusively for Inflight Motion Pictures, Inc., by Lockheed Aircraft Service, New York International Airport, Jamaica 30, N.Y.

Brumberger Reel Chests for storage of motion-picture reels and cans and magnetic tape reels are products of Brumberger, 68 34th St., Brooklyn 32, N.Y. Available in Economy and DeLuxe models and in various sizes, prices range from $3.25 for an Economy Model chest accommodating twelve 200-ft reels of 8mm film or 5-in. magnetic tape reels to $7.50 for a DeLuxe chest (with a device for automatic reel selection) which holds nine 400-ft reels of 16mm film or 7-in. magnetic tape reels.

Minute pencil tubes (so called because of the size and shape) designed by RCA's Electron Tube Division, Harrison, N. J., were installed in the Mercury Space Capsule's two-way radio system used for Earth-to-Space/Space-to-Earth communications in May while Astronaut Shepard was traveling in Space at the rate of 6000 ft/sec (more that 4000 mi/hr). The tube, designated RCA-5876, is an ultra-high-frequency high-gain triode. It was designed mainly for use in grounded-grid service as an r-f amplifier in transmitters or receivers operating up to 1000 mc/sec. Plans for a manned space flight in orbit, scheduled for later this year, include use of the RCA-5876 in the communication system.

Complete 16mm Laboratory

FAST QUALITY SERVICE

Negative or Reversal Processing
Color Duplicating
Black-and-White Duplicating
Editing
Sound Recording
Titling
Animation

Write for Price Schedules

Pan-American Films

735 POYDRAS STREET, NEW ORLEANS, LA., JACKSON 2-5364

Specialized
LIGHTING
EQUIPMENT
for MOTION PICTURE, STILL
and TELEVISION STUDIOS

Write for a copy of
Catalog H on Your Letterhead

Mole-Richardson Co.

937 NORTH SYCAMORE AVENUE, HOLLYWOOD 38, CALIF.

F & B PARADE OF PRODUCTS

F & B NICKEL CADMIUM BATTERIES

The perfect companion for your Arriflex, mounted in rugged aluminum case, with shoulder strap. Indestructible, high capacity Nickel Cadmium cells provide perfect power, absolutely guaranteed for 1 year.

7v. Battery (6 cells)	$85.00
10v. Battery (8 cells)	100.00
15v. Battery (12 cells)	135.00
Voltmeter attach. (opt)	20.00
Ammeter attach. (opt)	10.00
Miniaturized Charger	29.50
NEW—15v-7½v Battery—can be switched for 7½v or 15v for both 16mm and 35mm Arris	$155.00
With Built-In Charger	184.50

BELL & HOWELL GAUGES FOR FILMO REPAIR

S-4163-N2 Aperture Adjusting Gauge

S-3972-N1 Shuttle Teeth Gauge

This pair of precision tools cuts hours off Filmo repair time. Regular price for this set is $341.62. We offer these—in brand new condition—while they last—both gauges **$150**

Serving the World's Finest Film Makers

FLORMAN & BABB, Inc.

68 W. 45th St., New York 36, N. Y.

MUrray Hill 2-2928

F & B MAGIC MYLAR

A New Splicing and Repairing Technique

NOW IN NEW 20 FT. ROLLS

Only $2.20 for 16 mm; $4.04 for 35 mm

Please send me:

- ☐ 20 ft. rolls — transparent 16mm — single perforation (T16S) at $2.20
- ☐ 66 ft. rolls — transparent 16mm — single perforation (T16S) at $6.00
- ☐ 20 ft. rolls — transparent 16mm — double perforation (T16D) at $2.20
- ☐ 66 ft. rolls — transparent 16mm — double perforation (T16D) at $6.00
- ☐ 20 ft. rolls — transparent 35mm (T-35) at $4.04
- ☐ 66 ft. rolls — transparent 35mm (T-35) at $11.00
- ☐ 66 ft. rolls—white opaque—16mm—magnetic film only (0-16) at $6.00
- ☐ 66 ft. rolls — white opaque — 35mm (0-35) at $11.00
- ☐ ¼" splicing tape for magnetic tape (S4) at $.57

Name _____

Address _____

City _____

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Supervisory Photographic Technologist. Excellent instrumentation background obtained at four leading ordnance and missile Test Centers. Wide knowledge of cameras, lenses, mounts; including metric, engineering sequential, and documentary types. Broad film background. Supr. photo lab for 4 yrs. Purchasing and quality control background. Complete résumé upon request. Will relocate. Robert J. Millikin, 148 St. George Rd, Melbourne, Fla. PA 3-7819.

Cameraman/Producer. Extensive cine and still experience in training, public relations and industrial fields. Also experienced in cutting and sound recording. High-quality, low-budget script-to-screen producer. Interested in photo-instrumentation. Electronic engineering background. Recently completed Arctic assignment. Seeking challenging position in photography enabling use of past experience. Willing to travel and relocate worldwide. J.C.K., 3351 Alma St., Apt. 328, Palo Alto, Calif. DAvenport 6-2737.

Sound Recording Technician. Over 5 yrs experience in all phases of sound recording. Thoroughly familiar with mixing and recording sound for motion pictures, editing magnetic tapes and producing tapes for TV and radio. Interested in a permanent position with future. Willing to relocate. Thomas J. Hammeral, 137 92nd St., Brooklyn 9, N.Y. SH 5-7172.

Film Production Supervisor. 20 yrs experience in motion-picture and general photographic production. Presently in supervisory position in large inplant unit. Experienced in documentary, training and P.R. film productions. Do "A & B" cutting and sound recording. Hold Secret and "Q" Clearances. Resume upon request. Would consider Tech. Rep. position. Mo-pic, P.O. Box 9123, Montclair Station, Denver 20, Colo.

Positions Available

Assistant Chief Engineer. Seeking college graduate electronics engineer to assist Chief Engineer of commercial VHF television station in growing market. CBS affiliate; progressive management with long broadcast experience; good record of low personnel turnover. Majority of equipment RCA; two Ampex Videotape Recorders; maximum power; 1000-ft tower. Applicant should be capable of doing design and construction work, and should have some administrative ability. Salary commensurate with experience and ability. Replies treated in confidence. Write Chief Engineer, WLAC-TV, Nashville, Tenn.

Mechanical Engineer (Motion Picture Cameras). Must have Mech. Eng. degree. Prefer 3 yrs experience in design of professional motion-picture cameras for theatrical and instrumentation fields. Work involves design and manufacture of 16mm and 35mm professional double-system and single-system cameras as well as high-speed instrumentation cameras. Excellent opportunities. Submit detailed resume in triplicate to 126 Warren Rd., Park Ridge, N. J.

Sales Representative for well known motion-picture processing laboratory, N.Y.C. Experienced in laboratory processes, motion-picture production, sound recording and re-recording operations. Must be able to deal with professional cameramen, producers and directors in the advertising and educational fields. Salary open. Unusual opportunity for advancement. Outstanding company benefits. Send résumé in complete confidence, including salary desired, to: Hokar Corp., 110 West 40 St., New York, N.Y.

Assistant to Owner of Film Lab. Unusual opportunity for man who is expert in timing and printing 16mm color and black & white. Must also have basic knowledge of general business practices and be endowed with the ability to lead and supervise. Write to CINE-CRAFT, 8764 Beverly Blvd., West Hollywood 48, California.

Staff Director, for medium-sized production company located in Louisville, Kentucky. Must have credits for TV commercials, industrials and slidefilms. Basic requirement is a creative attitude. We offer unlimited opportunities, pay in accord with experience, and an expanding company with which to be associated. Although location work is to be expected, off hours are pleasantly spent in this friendly, midwestern community. All replies are held in confidence. Vogue Film Productions, Inc., Bowman Field, Louisville, Ky.

Motion-Picture Laboratory Engineer. Experienced in lab procedures, design and maintenance of motion-picture lab equipment. Knowledge of air conditioning, chemical piping and pumps desirable. Located New York City. Send resume giving experience and salary desired to Box 1979, 125 West 41 St., New York 36.

Television Broadcast Technician. Seeking experienced, qualified television technician for maintenance and operation at commercial VHF station in growing market. CBS affiliate; progressive management with long broadcast experience. Station is well-equipped; maximum power; 1000-ft tower; two Ampex Videotape Recorders. Applicant must be ambitious, dependable, and have First-Class Phone License. Some formal schooling in electronics preferred. Salary commensurate with experience and ability. Replies treated in confidence. Write Chief Engineer, WLAC-TV, Nashville, Tenn.

Photographic Instrumentation Technicians. Opportunities for qualified technicians exist in the Pacific Island area assisting in the operation of the Pacific Missile Range. Requirements: High level of technical competence, good moral character, single, widowed, or divorced (no housing presently available for married applicants). Position offers good pay, overtime premium, broad technical experience, chance for advancement with progressive company. Technical areas open: Operation maintenance of Askania theodolites, LA-24 (ME-16), M-45 tracking telescopes and high speed sequential cameras. Electronics capability very desirable. Positions also available for Photo Laboratory Technicians. Wide experience in all phases desirable. Ample opportunity for cross training in related fields. Many fringe benefits. Please submit resume to: Vought Range Systems Div., P.O. Box 51, Naval Missile Center, Pt. Mugu, Calif. Attn: H. S. Weisbrod, Photo-Optics Supervisor.

Résumés / Resumenes / Zusammenfassungen

The Society is extremely grateful to the following authors of papers appearing in this issue for providing translations of their abstracts: A. H. Lind—*German;* Aubrey Harris—*French, Spanish, German;* Gerald M. Seeley—*French, Spanish, German;* Pablo Tabernero—*Spanish, German;* J. S. Courtney-Pratt—*French, Spanish, German.*

Norme pour la mise en place du guide-vide dans les enregistreurs de ruban-image à piste transversale

A. H. Lind [485]

Le Comité d'Enregistrement de Rubans-Images SMPTE a mis au point une Technique Recommandée pour l'enregistrement sur ruban-image à piste transversale qui permet d'obtenir une longueur constante de piste-image enregistrée par période linéaire de télévision. L'observation de cette Technique Recommandée se traduira par une amélioration de l'interchangeabilité et de l'interjcintement des rubans enregistrés. La Technique Recommandée établit la position appropriée du guide-vide par rapport à l'axe de rotation des têtes à images en fonction du rayon du guide-vide. L'auteur décrit les bases de cette Technique Recommandée et explique les diverses relations qui y sont spécifiées.

Erreurs des bases de temps et leur correction dans les enregistreurs magnétiques de télévision

Aubrey Harris [489]

Durant le cours de l'enregistrement, dans un système d'enregistrement magnétique de télévision, la valeur du signal qui est fonction du temps est traduite par la magnétisation du milieu qui est fonction de l'espace. Cette opération de même que l'opération inverse, à voir la réproduction, peut créer des erreurs d'écarts du temps dans la réproduction de l'image.

Les facteurs influençant ces erreurs sont ressortis et discutés. Les méthodes de réduction des erreurs et de l'accroissement de la stabilité de la base du temps du signal de sortie par voie électromécanique et électronique sont décrites.

Equipement de film-câble

C. B. B. Wood, S. H. Padel et Peter Rainger [494]

Cet équipement est destiné à la transmission de courtes longueurs de film d'actualités de 16mm sur un réseau de programmes dans des câbles ou des systèmes de liaison radiophonique extra-longs. La durée de transmission est 100 fois plus longue que le temps normal de présentation du film. La réduction correspondante de la largeur de bande, ainsi que d'autres économies en fréquence, permettent de restreindre le signal à une largeur de bande-image de 4,5 kc qui occupe une bande entre 0,5 et 5,5 kc pour la transmission sur le circuit. L'equipement en question a été employé avec succès sur le câble transatlantique.

Un système de stabilisation pour améliorer la netteté et la fixité de l'image des tirages exécutés sur une tireuse 16mm continue

Gerald M. Seeley [498]

On décrit une modification simple du presseur d'une tireuse 16mm Bell et Howell Modèle J. On a mis un morceau de velours en face de la fenêtre de façon à obtenir un contact plus intime entte les films. Ceci réduit également les mouvements divers du film devant la fenêtre. (*Tr. par Claude Ramus*)

Un sensitomètre à exposition de l'ordre des microsecondes à temps constant et à intensité variable

Frank P. Herrnfeld [500]

Le sensitomètre à temps constant et intensité variable a été conçu et réalisé pour étudier la réaction des films photographiques dans la région d'exposition de l'ordre des microsecondes. Le temps le plus court réalisé à ce jour est de 1,5 μsec. avec 2 w/sec d'energie par éclair. Des temps d'exposition de 15 et 150 μsec à un niveau d'énergie identique par éclair sont également disponibles.

Réalisation et maintien du chromo-équilibre entre tireuse et lumière dans le tirage à couleur additive par un système d'aléas contrôlés

Pablo Tabernero [502]

Le problème présenté dans ce mémoire ne concerne pas le procédé de réglage des négatifs en couleur, mais la nécessité de maintenir une qualité uniforme de couleur d'un tirage à l'autre. Il importe d'établir un chromo-équilibre déterminé pour un ensemble donné de conditions de tirage. Cet équilibre dépend souvent de divers inconnus tels que les changements de la sensibilité relative des matières de tirage à l'égard de la couleur entre un revêtement et le suivant. L'auteur mentionne les conditions générales de stabilité d'un procédé de tirage additif. Il définit un système d'aléas contrôlés. L'article précise les points essentiels du système proposé. On y indique également quelques raisons mathématiques à la base du choix d'un nombre suffisant et de l'ordre des combinaisons expérimentales possibles entre la tireuse et la lumière. L'auteur discute succintement les considérations économiques de l'équipement.

Quelques utilisations des masers optiques en photographie

J. S. Courtney-Pratt [509]

Cet obturateur offre beaucoup des avantages des obturateurs magnéto-optiques habituels et évite quelques-uns de leurs inconvénients. L'inductance doit être très petite, et l'on doit être à même de réaliser des temps de pose de l'ordre de la nanoseconde.

Applications de la caméra multi-images à miroir tournant de type C5

K. R. Coleman et A. Skinner [512]

Il a été présenté à la réunion de Cologne cinq mémoires séparés décrivant divers aspects des travaux de photographie à haute sensibilité qui ont été effectués à l'Etablissement des Recherches en Armes Atomiques Anglaises. Le présent mémoire décrit trois applications de la caméra de type C5 à des vitesses allant jusqu'à 7×10^6 images par seconde pour l'étude de phénomènes tels que les décharges à mode Θ et les effets d'explosions à éclairage extérieur.

Qu'est-ce que la sensibilité d'un système photographique?

Fred H. Perrin [515]

La notion de sensibilité informative est dérivée intuitivement comme représentant le gradient $g = dD/dE$ divisé par le produit de la granularité Selwyn G et de la racine carrée de la superficie s de la fonction dispersion. Quand le diamètre de l'objectif de l'appareil et les dimensions de l'image finale sont maintenus constants, la distance focale relative de cet objectif pour une reproduction égale des détails varie en fonction directe du produit $G\sqrt{s}$. Le temps d'exposition nécessaire varie donc en fonction inverse de la sensibilité informative $g/G\sqrt{s}$. Pour un appareil photographique fixe, la reproduction des détails s'améliore à mesure que la distance focale de l'objectif de l'appareil augmente. Toutefois, le temps d'exposition augmente aussi et, lorsque l'appareil se déplace par rapport à la scène, la reproduction des détails se trouve ainsi diminuée par suite de cette cause et est optima pour une certaine distance focale. L'auteur donne des exemples à l'appui des ces conclusions.

Un appareil de prise de vues à élément Kerr avec source lumineuse synchronisée pour la photographie à lumiére réfléchie de l'ordre des millimicrosecondes

George A. Theophanis [522]

Certains processus susceptibles d'être étudiés photographiquement sont associés à un haut degré d'auto-luminosité. Afin d'étudier les phénomènes de surface de ces processus, on a réalisé un appareil de prise de vues à élément Kerr de 50 mμsec à haute résolution, ainsi qu'une source de lumiére synchronisée. On utilise un élément Kerr à trois polariseurs, dont le rapport de transmission optique est supérieur à 10^6:1, pour éviter toute exposition excessive de la pellicule par suite de la lumière de durée relativement longue provenant de l'auto-luminosité qui s'infiltrerait lors de la fermeture d'un élément à deux polariseurs de type ordinaire. L'élément est excité au moyen d'un générateur de pulsation de ligne de transmission capable de produire une pulsation à ondes de profil carré de 60.000 v.

La source lumineuse consiste en trois tubes-éclair remplis de xénon de type commercial qui sont amorcés au moyen d'un pulsateur thyatron à hydrogène. Un réseau de ligne de transmission est incorporé au pulsateur du tube-éclair afin de produire une pulsation synchronisante de haut voltage quand les tubes-éclair sont allumés. Cette pulsation est appliquée par l'intermédiaire d'une longueur de câble à retard à l'électrode de déclenchement du commutateur de distance explosive qui actionne l'obturateur de l'élément Kerr. La synchronisation est accomplie avec une précision de 5 mμsec. L'appareil de prise de vues a été employé pour photographier les premières phases de feuilles métalliques explosées électriquement, ainsi que les chocs aux hypervitesses dans un polygone balistique.

L'intensification électronique de l'image: Un intensificateur d'image utilisant la cathodo-conductivité

R. A. Chippendale et J. R. Folkes [527]

De récents travaux effectués sur un intensificateur électronique d'image microscopique ont démontré que des pellicules minces de sélénium amorphe peuvent donner une multiplication de charge d'environ 2000 quand on les bombarde d'électrons à haute énergie. Les anteurs décrivent un tube hermétiquement fermé qui produit une amplification avant exploration dans une pellicule au sélénium du même genre. Dans la fonction "enregistrement," les électrons émanant d'une cathode photo-émissive demi-transparente sont covergés et accélérés de manière à pénétrer dans une pellicule au sélénium auto-porteuse de 10 microns. L'emploi d'une plaque-signal transparente à électrons sur la surface antérieure de la pellicule permet aux charges d'être chassées à l'arrière d'où elles sont enlevées par un faisceau explorateur à bas voltage qui ramène la surface au potentiel normal de la cathode émettrice. On emploie l'exploration électrostatique en combinaison avec des électrodes inductrices retardatrices pour réaliser l'orthogonalité.

La sensibilité d'ensemble dépend d'une part du rendement photocathodique et d'autre part de la multiplication des charges dans le sélénium qui est à son tour fonction du voltage des électrons d'enregistrement. On peut démontrer théoriquement que l'emploi d'une largeur de bande maintenue dans certaines limites et de conditions optima d'amplification doit permettre de déceler des photoélectrons isolés. Des essais avec des tubes ont démontré qu'une amplification de 500 avant exploration devrait être praticable. Dans ce cas le tube devrait être capable de déceler 40 photons par point image par image.

Una norma para la posición de la guia de vacio en las grabadoras de cinta magnética de video tipo impresión transversal

A. H. Lind [485]

El Comité de la SMPTE para Grabación de Cinta Magnética de Video ha desarrollado una Norma Recomendada para la grabación de cinta magnética de video tipo impresión transversal que permite obtener una relación constante entre el largo de grabación de video y el periodo de linea de TV. El adjustarse a esta Norma Recomendada mejorarà la intercambiabilidad e interempalmeabilidad de cintas grabadas. La Norma Recomendada establece la posición correcta de la guia de vacio con respecto al eje de rotación de las cabezas de video como una función del radio de la guia de vacio. Los antecedentes a esta Norma Recomendada son esbozados y las relaciones especificadas en ella, son explicadas.

Correccion de errores en base de tiempo en grabadores de cinta de television

Aubrey Harris [489]

Durante el proceso de grabacion en un sistema de cinta magnetica de television, las relaciones de base de tiempo que existen entre las varias partes de la forma de onda de la senal son transferidas al medio de grabacion en la forma de distancia. Este proceso, y se inverso que ocurre durante la reproduccion, puede causar errores indeseables en la base de tiempo de la imajen reproducida.

Los factores que causan estos errores son delineados y discutidos; como tambien los metodos de reducir los errores y de incrementar la estabilidad de las senales de salida, por medios electronicos y electromecanicos.

Equipo transmisor de peliculas por cable o radio ("Cablefilm")

C. B. B. Wood, S. H. Padel, y Peter Rainger

El equipo está diseñado para la transmisión de tramos cortos de noticieros de 16 mm a un canal de programas en sistemas bien largos de enlace por cable o radio. El tiempo de transmisión es 100 veces el tiempo normal de correr la pelicula. La reducción correspondiente en ancho de banda junto con otras economias en la frecuencia permite reducir la señal a un ancho de banda de video de 4.5 kc, ocupando una banda entre 0.5 y 5.5 kc para su transmisión sobre el circuito. Este equipo ha sido usado con éxito por cable transatlántico.

Un artefacto de amortiguamiento para mejorar el agudeza del imagen y la estabilidad de copias hechas en un impresor continuo de pelicula cinematografica de 16mm

Gerald M. Seeley [498]

Se describa una modificación sencilla al patín del ventanillo de un impresor Bell & Howell Model J. Una almohadilla de terciopelo Rayon se coloca sobre la ventanilla del impresor tan que el contacto de una pelicula con una otra sea más intimo. Esto tambien reduce los movimientos espurios de la pelicula en la ventanilla. (*Tr. de Mrs. E. W. Tapia*)

Un sensitómetro de tiempo constante, intensidad variable para exposiciones de microsegundos

Frank P. Herrnfeld [500]

El sensitómetro de tiempo constante e intensidad variable fué diseñado para investigar la reacción de película fotográfica en la zonade exposición de microsegundos. El tiempo mas rápido disponible es de 1.5 μseg con 2 wseg de energia por destello. Tambien se disponse de tiempos de exposición de 15 y 150 μseg a idéntico nivel de energia por destello.

Como establecer y mantener el balance de color de copiadora al hacer copias aditivas en colores mediante un sistema de azar controlado

Pablo Tabernero [502]

El problema de que trata este artículo no se refiere a procedimientos de clasificación del Negativo de Color sinó a la necesidad de mantener una calidad uniforme del color de una copia a la siguiente. Un balance de color determinado debe ser establecido para un conjunto dado de condiciones de copia. Este balance dependerá muchas veces de cantidades incógnitas, tales como variaciones en la sensibilidad relativa de color de los materiales positivos, de un número de emulsión a otro. Se mencionan condiciones generales para la estabilidad de un proceso de copia aditiva. Se define un sistema de azar controlado. Se enumeran y describen las partes esenciales del sistema propuesto. Se discuten algunas razones matemáticas para la selección de un número y secuencia adecuados de posibles combinaciones de ensayo de luces de copiadora. Se discuten brevemente consideraciones económicas.

Diversos usos de rayos de luz maser en la fotografía

J. S. Courtney-Pratt [509]

El extraordinario brillo de un rayo convergente maser hace del mismo un foco ideal para la micrografía de alta amplificación con breve tiempo de exposición, y para trabajos esquiagráficos y schlieren. El monocromatismo del rayo de luz hace además que el foco maser sea excepcionalmente útil en la interferometría. Para demostrar ciertas potencialidades de los focus de luz maser se presentan algunas fotografías.

Usos de la camara tipo C5 de fotogramas con un espejo girandor

K. R. Coleman y A. Skinner [512]

A la reunión en Colonia, se han presentado cinco papeles diferentes describiendo unos aspectos del trabado fotográfico de alto velocidad desarrollado en el Establecimiento Británico para Investigación de Armas Atomicas. En este papel los escritores describen tres usos de la cámara tipo C5 a velocidades hasta 7 x 10^6 fotogramas/sec. para fotografiar unos tales acontecimientos como las descargas Q-modo y los efectos de explosiones iluminados del exterior.

Que es la sensibilidad de un sistema fotografica?

Fred H. Perrin [515]

El concepto de sensibilidad informacional se deriva intuitivamente como el gradiente g-dD/dE dividido por el producto de granulosidad Selwyn $\mathcal{G}$ y la raís cuadrada de la área s de la función envergadora. Cuando el diámetro del lente de la cámare y el tamaño de la fotografía final son tenido invariable, la distancia focal relativa del lente de la cámara para una registración igual de todos los detalles varia directamente con el producto $\mathcal{G}\sqrt{s}$. En seguida, el tiempo de exposición requerido varia inversamente con la sensibilidad informacional $g/\mathcal{G}\sqrt{s}$. Con una cámara estacionaria, la registración de detalles mejora con cada aumento de la distancia focal del lente de la cámara. Pero el tiempo de exposición aumenta, también, y cuando se mueve la cámara relativamente a la escena, la registración de detalles disminuye de esta causa y está optimum a una distancia focal especifica. Se dan varios ejempolos para confirmar estas conclusiones.

Una camera a elemento Kerr con un fuente de luz sincronizado fotografia de milimicrosegundo a luz reflejada

George A. Theophanis [522]

Ciertos acontecimientos susceptible de estar, estudiado fotograficamente son asociado á un grado de auto-liminosidad. Para estudiar los fenominos de superficie de estos acontecimientos, se ha realizado una cámara a elemento Kerr de 50 μsec á resolución alta, teniendo un fuente de luz sincronizado. Se ha usado un elemento Kerr á tres polarizadores de quienes el producto de transmisión optica está superior a 10^6:1, para evitar toda exposicion excesiva de la película debida á la duración relativamente larga de la luz saliende de auto-luminosidad que se infiltra de el cerrado de un elemento á dos polarizadores de un tipo ordinario. El elemento está excitado por el medio de un generador de pulsación de linea de transmisión con la capacidad de producir una pulsación á ondas-cuadradas de 60,000 v.

El fuente luminoso consiste en tres tubos-flash llenado con xenon de tipo comercial que son disparados por el medio de un generador de pulsación tiatron á hidrógeno. Un red de linea de transmisión está agregado en el pulsador del tubo-flash para producir una pulsación sincronizada de voltaje alta cuando los tubos-flash son encendido. Esta pulsación está aplicado por via de una largura de cable á dilación á electrodo disparado del interruptor á la distancia disruptiva que activa el obturador á Kerr elemento. La sincronización está efectuada con una precisión de 5 μsec. Se ha usado la cámara para fotografiar las fases primeras de láminas metálicas electricamente estalladas, asi como los choques á hipervelocidad en un alcance de balistica.

Intensificacion electronica de la imagen: Un intensificador de la imagen usando la conductividad catodica

R. A. Chippendale y J. R. Folkes [527]

Unos trabajos recientes sobre un intensificador electrónico de la imagen microscópica han demostrado que unas películas delgadas de selenio amorfo pueden dar una multiplicación de carga cerca de 2000 cuando se las bombardea con los electronos de energía alta. Los escritores describen un tubo hemèticamente sellado que produce una amplificación delante de explorar en una película de selenio de la misma clase. En la función "registrando," los electronos emanado de un cátodo foto-emisivo semitransparente son enfocados y se despachados en una manera para penetrar en una película de selenio sosteniendose de 10 micrones. El uso de una placa-señal transparente del electronos sobre la superficie anterior de la película permite las cargas de estar empujado al fondo de donde ellas son eliminadas por un rayo explorador de voltaje bajo que vuelve la superficie a la potencial normal del cátodo emitador. Se emplea la exploración electrostática en combinación con unos electrodos inductivos retardadores para realizar la ortogonalidad.

La sensibilidad total depende tanto en los rendimientos fotocatódicos como en la multiplicación de las cargas en el selenio que es en su vuelta una función del voltaje de los electronos del registrador. Se puede demostrar teóricamente que el uso de una anchura de banda mantenida en limites ciertos y de condiciones optima de amplificación debe permitir de manifestar unos foto-electronos únicos.

Unas pruebas de tubos experimentales han demostrado que unas ganancias delante de explorer de 500 debe ser posible. En caso de eso, el tubo debe tener la capacidad de descubrir 40 fotones incidentes por punto de imagen cátodo por fotograma.

Eine Norm für die Einstellung der Vakuumführung in Video-Bandaufnahmegeräten mit transversaler Spur

A. H. Lind [485]

Das SMPTE Video-Tape Recording Committee hat praktische Empfehlungen für transversale Video-Bandaufnahmetechnik aufgestellt, die konstante Länge der Aufnahmespur für die Zeilendauer zum Gegenstand haben. Die Austauschbarkeit und Zusammensetzbarkeit der Bandaufnahmen wird hierdurch verbessert. Die Empfehlungen geben die erforderliche Lage der Vakuumführung in Bezug auf die Rotationsachse der Aufnahmeköpfe als Funktion des Radius der Vakuumführung an. Es werden Unterlagen für die Empfehlungen angegeben und die darin enthaltenen Beziehungen erklärt. (*Ub. von H. H. Behling*)

Zeitbasis-Abweichungen und ihre Korrektur in magnetischen Televisionsaufnahmegeräten

Aubrey Harris [489]

In einem magnetischen Televisionsaufnahme-System werden die Zeitverhältnisse der verschiedenen Teile des Signals auf den Aufnahmeträger im Zusammenhang zur Distanz übertragen. Diese Operation und das umgekehrte Verhältnis, das bei der Wiedergabe auftritt, kann unerwünschte Zeitverschiebungsfehler im reproduzierten Bild verursachen.

Die Faktoren, die diese Abweichungen beeinflussen, werden dargelegt und besprochen. Methoden, diese Abweichungen zu verringern und die Zeitstabilität der Signale auf elektromechanischen und elektronischen Wegen zu vergrössern, werden beschrieben.

Kabelfilmvorrichtung

C. B. B. Wood, S. H. Padel und Peter Rainger [494]

Diese Vorrichtung ist für die Übertragung kurzer 16 mm Nachrichtendienstfilme über ein Programmkanal sehr langer Kabel oder Richtfunksysteme bestimmt. Die Übertragungszeit ist 100 mal grösser als die normale Laufzeit des Films. Die entsprechende Verringerung der Bandbreite in Zusammenhang mit anderen Einschränkungen der Frequenz ermöglicht es, das Signal auf eine Fernsehbandbreite von 4,5 KH, die eine Band von 0,5 bis 5,5 KH einnimmt, zur Übertragung über den Stromkreis zu beschränken. Die Vorrichtung wurde erfolgreich für transatlantische Kabelübertragung angewandt.

Eine Klapp-Vorrichtung zur Verbesserung der Bildschärfe und Stetigkeit von auf einer kontinuierlichen 16mm Kinofilm-Kopiermaschine gemachten Kopien

Gerald M. Seeley [498]

Eine einfache Abänderung des Filmfenster-Schuhs einer 16mm- Bell & Howell-Kopiermaschine, Modell J, wird beschrieben. Ein Rayonsamt-Polster ist über der Kopieröffnung derartig angeordnet, dass ein innigerer Kontakt von Film zu Film hergestellt wird. Dies verringert auch falsche Filmbewegungen am Fenster. (*Ub. von Dr. Kellner*)

Ein Sensitometer für Mikrosekunden-belichtungen mit gleichbleibender Zeit und veränderlichen Intensität

Frank P. Herrnfeld [500]

Der Sensitometer mit gleichbleibender Zeit und veränderlicher Intensität wurde konstruiert um die Empfindlichkeit photographischer Filme im Belichtungsbereich der Mikrosekunden zu untersuchen. Die schnellste verfügbare Zeit beträgt 1,5 μSek. mit einer 2 W/Sek. Energie pro Blitz. Belichtungszeiten von 15 und 150 μSek. bei gleichem Energiegrad pro Blitz sind auch verfügbar.

Verfahren zur festlegung und Aufrechterhaltung des Kopierlicht-Farbgleichgewichts bei der additiven Farbkopie, mittels eines Proben-Systems mit kontrollierter Wahrscheinlichkeit

Pablo Tabernero [502]

Der vorliegende Artikel bezieht sich nicht auf das Problem der Ausführung der Lichtbestimmung von Farbnegativen, sondern auf die Notwendigkeit der Aufrechterhaltung einer gleichmässigen Qualität der Farbe von einer Kopie zur nächsten. Es handelt sich darum unter gegebenen Kopierbedingungen ein vorbestimmtes Farbgleichgewicht zu erreichen. Dieses hängt oftmals von unbekannten Grössen ab, wie zum Beispiel Unterschiede in der relativen Farbempfindlichkeit verschiedener Positivemulsionen. Es werden allgemeine Bedingungen für die Stabilität eines additiven Kopierverfahrens erwähnt. Es wird ein System für die Kontrolle der Wahrscheinlichkeit des Erscheinens der gewünschten Farbprobe definiert. Es werden die wesentlichen Teile des vorgeschlagenen Systems aufgezählt und beschrieben. Einige rechnerische Grundsätze für die Auswahl einer geeigneten Anzahl und Folge von möglichen Kopierlichtprobekombinationen werden besprochen. Es wird einiges Weniges über die Wirtschaftlichkeit des Verfahrens gesagt.

Einige photographische Anwendungsmöglichkeiten für optische Maser

J. S. Courtney-Pratt [509]

Durch die ausserordentliche Helligkeit des brennpunktscharfen Maser-Strahles ist eine ideale Lichtquelle für Hochvergrösserungs-Mikrographie bei kurzer Belichtung, für Schattenrissaufnahmen und auch für Schlierenlichtbilder geschaffen worden. Die Monochromasie des Strahles verleiht der Maser-Lichtquelle weiterhin ausserordentliche Bedeutung für interferometrische Untersuchungen. An Hand von Aufnahmen werden einige Anwendungsmöglichkeiten der Maser-Lichtquelle vorgeführt.

Anwendung der Rotationsspiegelkamera mit hoher Verschlussgeschwindigkeit

K. R. Coleman und A. Skinner

Während der Tagung in Köln wurden fünf verschiedene Arbeiten vorgelegt, in denen die verschiedenen Anwendungsmöglichkeiten der Hochfrequenzphotographie, wie sie in den Britischen Atomwaffen-Versuchslaboratorien zur Anwendung kamen, besprochen wurden. Die vorliegende Arbeit beschreibt drei Anwendungsmöglichkeiten des C-5 Kameratyps bei Geschwindigkeiten bis zu 7 x 10^8 Bild/Sek, im Falle solcher Erscheinungen, wie die Θ-Entladung und die von aussen beleuchteten Explosionswirkungen.

Was ist die Empfindlichkeit eines photographischen Systems?

Fred H. Perrin [515]

Der Begriff der Informationsempfindlichkeit wird anschaulich abgeleitet als der Gradient $g = dD/dE$ geteilt durch das Produkt der Selwyn-Körnigkeit β und der Quadratwurzel der Fläche s der Ausbreitungsfunktion. Falls der Durchmesser der Kameralinse und die Grösse des endgültigen Bildes konstant bleiben, dann verändert sich für die gleiche Wiedergabe der Einzelheiten die relative Brennweite der Kameralinse unmittelbar mit dem Product $\beta\sqrt{s}$. Die erforderliche Belichtungszeit verändert sich dann im umgekehrten Verhältnis zum Produkt $g/\beta\sqrt{s}$. Im Falle einer stationären Kamera verbessert sich die Wiedergabe der Einzelheiten, insoweit als die Brennweite der Kameralinse vergrössert wird. Aber die Belichtungszeit wird gleichweise erhöht und wenn sich die Kamera im Verhältnis zum Aufnahmeobjekt bewegt, dann wird die Wiedergabe der Einzelheiten durch diesen Umstand beeinträchtigt, wobei diese auch das Optimum für eine gewisse Brennweite darstellt. Angeführte Beispiele bestätigen diese Schlussfolgerungen.

Eine Kerrzellen-Kamera mit Synchronisierter Lichtquelle für die Millimikrosekunden-Photographie bei Reflektiertem Licht

George A. Theophanis [522]

Gewisse Vorgänge, welche sich photographisch untersuchen lassen, besitzen einen hohen Grad eigener Lumineszenz. Um die sich an der Oberfläche zeigenden Erscheinungen solcher Vorgänge studieren zu können wurde eine Kamera entwickelt, die eine hohes Auflösevermögen zeigt und mit einer Kerrzelle von 50 Millimikrosekunden versehen ist und zu der eine synchronisierte Lichtquelle gehört. Infolge der verhältnismässig langen Dauer würde Licht der Eigenlumineszenz durch eine gewöhnliche, doppelt polarisierte Kerrzelle dringen und eine unerwünschte Belichtung des Films verursachen weshalb eine dreifach polarisierte Kerrzelle verwendet wird, die ein optisches Durchlass-

verhältnis von mehr als 10⁸:1 besitzt. Die Zelle wird durch einen Übertragungsleitung- Impulsgenerator aktiviert, der imstande ist einen 60.000 V Rechteckwellen-Impuls zu liefern.

Die Lichtquelle besteht aus drei handelsüblichen mit Xenon gefüllten Blitzröhren, welche durch einen Wasserstoff-Thyatron Impulsgeber aktiviert werden. In den Impulsgeber der Blitzröhre wurde ein Übertragungsleitungssystem eingebaut, um einen Synchronisierimpuls hoher Spannung zu erzeugen, sobald die Blitzröhren aufflammen. Dieser Impuls wird durch ein Verzögerungskabel zir Auslöse-Elektrode des Luftspaltschalters geleitet, der den Verschluss der Kerrzelle betätigt. Die Synchronisation geschieht mit einer Genauigkeit von 5 Millimikrosekunden. Die Kamera wurde dazu benützt die ersten Stadien elektrisch explodierter Metallfolien und Höchstgeschwindigkeits-Aufschläge auf einer Schiesstätte zu photographieren.

Elektronische Bildverstärkung: Bildverstärker benutzt Kathoden-Leitungsfähigkeit

R. A. CHIPPENDALE und J. R. FOLKES

[527]

Durch jüngst vorgenommene Arbeiten an dem Bildverstärker eines Elektronenmikroskops wurde festgestellt, dass dünne Schichten von amorphem Selen, wenn mit Hochenergie-Elektronen bombardiert, die Aufladung um ungefähr das 2000 fache vervielfachen können. Es wird eine geschlossene Röhre beschrieben, welche eine Verstärkung vor dem Abtasten in einer solchen Selenschicht erzielt. Bei der "schreibe"-Funktion werden Elektronen einer halbtransparenten photonausstrahlenden Kathode gesammelt und in eine nicht gestützte Selenhaut von 10 Mikrons hineinbeschleungit. Dadurch dass an der Vorderseite dieser Haut eine elektronendurchlässige Signalplatte vorgesehen ist, können die Landungen nach rückwärts getrieben werden, von wo sie durch einen Abtaststrahl niedriger Spannung entfernt werden, der die Oberfläche wieder auf das Potenzial der Ablesekathode zurückbringt. Um Rechteckigkeit zu erzielen wird elektrostatisches Abtasten in Verbindung mit verzögernden Feldelektroden verwendet.

Die Gesamtempfindlichkeit hängt sowohl von der Wirksamkeit der Photokathode wie auch von der Ladungsvervielfachung im Selen ab, die selbst von der schreibenden Elektronenspannung abhängig ist. Es lässt sich theoretisch beweisen, dass es bei Verwendung einer entsprechend beschränkten Bandbreite und optimalen Verstärkungsverhältnissen möglich sein sollte, einzelne Photoelektronen zu entdecken. Untersuchungen mit experimentellen Röhren haben gezeigt, dass eine Verstärkung von 500 vor dem Abtasten möglich sein sollte. In diesem Fall sollte die Röhre fähig sein, 40 Photonen je Bildpunkt der Kathode je Bild zu entdecken.

Ed. Note: Titles and abstracts of all papers published in the *Journal* are published in French, Spanish and German. This department (Résumés/Resumenes/Zusammenfassungen) was set up in recognition of the growth in the Society's overseas membership, and first appeared as a regular feature of the *Journal* in the January 1961 issue. Comments and suggestions are invited on the quality and possible improvement of the translations. Because of the prohibitive cost of commercial translations, volunteer help is needed, and such assistance will represent an important contribution to the Society. Contributors will, of course, be given full acknowledgment in the *Journal*.

Volume 1 Series II

Instrumentation and High-Speed Photography

Newest in the series of high-speed photography reprint volumes.
42 articles reprinted from the Journal of the SMPTE on:

- *light sources*
- *optics & visibility studies*
- *cameras & accessories*
- *cathode-ray tubes*
- *television in instrumentation*
- *very high-speed systems*
- *processing & processing machines*
- *military & industrial applications*

$4.00

187 pp. Many illustrations.
Abstracts in French and German.
Cumulative index of previous volumes.

Available only for cash with order or by Company Purchase Order
20% discount to SMPTE members, libraries and booksellers, postage paid

5 through 49 copies at $4.00 each, less 25%, plus foreign postage
50 copies or more at $4.00 each, less 33⅓%, plus foreign postage
Within New York City, add 3% Sales Tax

Society of Motion Picture and Television Engineers
55 West 42 Street, New York 36, N.Y.

Contents — pages 541–580

News Columns

90th SMPTE Convention Announcement 541
89th Convention—Toronto, Canada 542
Education, Industry News 556
Biographical Note: Arthur C. Hardy 564
Section Reports 566
New Products 571
Employment Service 576
Résumés-Resumenes-Zusammenfassungen 577

Advertisers

Allen Products, Inc. 571
Arriflex Corp. of America 567
Bach Auricon, Inc. 559
Burke & James, Inc. 574
Camera Equipment Co. 549, 560
Camera Mart, Inc. 556
Fish-Schurman Corp. 558
Florman & Babb, Inc. 553, 576
General Film Laboratories, Inc. 551
Gevaert Photo Producten N.V. 557
Barry Green 564
Hollywood Film Co. 547
Kling Photo Corp. 545
La Vezzi Machine Works 573
Magnasync Corp. 561
Magna-Tech Electronic Co., Inc. 563
Marconi's Wireless Telegraph Ltd. 565
Mole-Richardson Co. 575
Motion Picture Laboratories, Inc. 562
Movielab Film Laboratories, Inc. 555
Moviola Mfg. Corp. 572
Pan American Films 575
Peerless Film Processing Corp. 569
Prestoseal Mfg. Corp. 570
Professional Services 568
SMPTE 548, 580
S.O.S. Photo-Cine-Optics, Inc. 569
Texas Industrial Film Co. 566
Wollensak Optical Co. 554

Meeting Calendar

USSR Ministry of Culture and Union of Cinematographers, 2nd International Film Festival, July 9–23, Moscow, USSR.

IFME, JECMB, IRE-PGBME, 4th International Conference on Medical Electronics and 14th Conference on Electronic Techniques in Medicine and Biology, July 16–21, Waldorf-Astoria Hotel, New York.

NAVA, Annual Convention, July 22–25, Hotel Morrison, Chicago.

American Rocket Society, Guidance and Control Conference, Aug. 7–9, Stanford Univ., Stanford, Calif.

SPIE, National Convention, Aug. 7–10, Ambassador Hotel, Los Angeles.

Western Electronic Show and Convention, Aug. 22–25, San Francisco.

American Chemical Society, 6th International Conference on Coordination Chemistry, Aug. 27–Sept. 1, Wayne State Univ., Detroit, Mich.

UFPA, Annual Meeting, Aug. 20–26, Berkeley Campus, U. of California.

American Chemical Society, National Meeting, Sept. 3–8, Chicago.

IRE, National Symposium on Space Electronics and Telemetry, Sept. 6–8, Albuquerque, N.M.

PGIT, International Symposium on Transmission and Processing of Information, Sept. 6–8, MIT, Cambridge, Mass.

AIEE, ISA, IRE, Joint Nuclear Instrumentation Symposium, Sept. 6–8, North Carolina State College, Raleigh, N.C.

ISA, Fall Instrument-Automation Conference and Exhibit, Sept. 11–15, Memorial Sports Arena, Los Angeles.

Electronic Industries Association, Annual Meeting, Sept. 12–14, New York.

Standards Engineers Society, Annual Meeting, Sept. 18–20, Hotel Sherman, Chicago.

IRE, AIEE, Industrial Electronics Symposium, Sept. 20–21, Boston, Mass.

AICE, National Meeting, Sept. 24–27, Lake Placid Club, Lake Placid, N.Y.

Illuminating Engineering Society, National Technical Conference, Sept. 24–29, Chase-Park Plaza Hotel, St. Louis, Mo.

Electrochemical Society, Fall Meeting, Oct. 1–5, Statler Hotel, Detroit, Mich.

IRE, Canadian Electronic Conference, Oct. 2–4, Automotive Bldg., Exhibition Park, Toronto, Ont.

90th Semiannual Convention of the SMPTE, Oct. 1–6, Lake Placid, N.Y.

American Rocket Society, Twelfth International Astronautical Congress, Oct. 2–7, Washington, D. C.

National Electronics Conference, Oct. 9–11, International Amphitheatre, Chicago.

American Rocket Society, Space Flight Report to the Nation, Oct. 9–15, New York Coliseum, New York.

American Standards Association, National Conference, Oct. 10–12, Rice Hotel, Houston, Texas.

AIEE, Fall General Meeting, Oct. 15–20, Statler-Hilton Hotel, Detroit.

ASCE, Annual Meeting, Oct. 16–20, Hotel Statler, New York.

Air Force Office of Scientific Research, Second International Conference on the Exploding Wire Phenomenon, Nov. 14–16, Boston, Mass.

ASME, Annual Meeting, Nov. 26–Dec. 1, Hotel Statler, New York.

Society of Reproduction Engineers, Visual Communications Congress, Dec. 1–4, Hotel Biltmore, Los Angeles.

AICE, Annual Meeting, Dec. 3–7, Hotel Commodore, New York.

American Association for the Advancement of Science, Annual National Meeting, Dec. 26–31, Denver Hilton, Brown Palace, Cosmopolitan, Shirley Savoy Hotels, Denver, Colo.

AIEE, Winter General Meeting, Jan. 28–Feb. 2, 1962, Hotel Statler, New York.

AICE, National Meeting, Feb. 4–7, 1962, Statler-Hilton, Los Angeles.

91st Semiannual Convention of the SMPTE, Apr. 29–May 4, 1962, Ambassador Hotel, Los Angeles.

6th International Congress on High-Speed Photography, Sept. 17–22 1962, Hotel Kurhaus, Scheveningen, Netherlands.

92nd Semiannual Convention of the SMPTE, Oct. 21–26, 1962, Drake Hotel, Chicago.

93rd Semiannual Convention of the SMPTE, Apr. 21–26, 1963, Traymore Hotel, Atlantic City, N.J.

94th Semiannual Convention of the SMFTE, Oct. 13–18, 1963, Somerset Hotel, Boston.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters and of the Committee Chairmen and Members were published in the April 1961 Journal.

sustaining members

of the Society of Motion Picture and Television Engineers

The objectives of the Society are:

- Advance in the theory and practice of engineering in motion pictures, television and the allied arts and sciences;
- Standardization of equipment and practices employed therein;
- Maintenance of high professional standing among its members;
- Guidance of students and the attainment of high standards of education;
- Dissemination of scientific knowledge by publication.

Progress toward the attainment of these objectives is greatly aided by the financial support provided by the member companies listed below.

Acme Film Laboratories, Inc.
Alexander Film Co.
Alex Laboratorios Cinematograficos S.A.
Altec Service Company
  Altec Lansing Corporation
American Broadcasting-Paramount Theatres, Inc.
  ABC-TV Network
  ABC Films, Inc.
Ampex Video Products Company
Animation Equipment Corp.
Ansco
Arriflex Corp. of America
C. S. Ashcraft Mfg. Company, Inc.
The Association of Cinema Laboratories, Inc.
Association of Professional Cinema Equipment Dealers of New York
  Camera Equipment Company, Inc.
  The Camera Mart, Inc.
  Florman & Babb, Inc.
  S.O.S Photo-Cine-Optics, Inc.
Atlas Film Corporation
Audio Productions, Inc.
Bach Auricon, Inc.
Bausch & Lomb Incorporated
Beckman & Whitley, Inc.
Bell & Howell Company
Bonded Film Storage
  (Division of Novo Industrial Corp.)
Brooks Cameras & Supply
Byron Motion Pictures, Inc.
S. W. Caldwell Ltd.
Calvin Productions, Inc.
Capital Film Laboratories, Inc.
Oscar F. Carlson Company
Cellomatic Company of Canada
  Division of Peelcraft Ltd.
Century Lighting, Inc.
Century Projector Corporation
Cineffects, Inc.
Cinesound, Ltd., Canada
Geo. W. Colburn Laboratory, Inc.
Color Reproduction Company
Color Service Company, Inc.
Columbia Broadcasting System, Inc.
  CBS Television Network;
  CBS Television Stations; CBS News;
  CBS Films; Terrytoons
Commonwealth Filmcraft Laboratories Pty. Ltd.
Comprehensive Service Corporation
Consolidated Film Industries
DeFrenes Company
DeLuxe Laboratories, Inc.
Desilu Productions, Inc.
Du Art Film Laboratories, Inc.
  Tri Art Color Corporation
E. I. du Pont de Nemours & Co., Inc.
Eastern Effects, Inc.
Eastman Kodak Company
Edgerton, Germeshausen & Grier, Inc.
Edisco, Inc.
Elgeet Optical Company, Inc.
Max Factor & Co.
Fairchild Camera & Inst. Corp.
  Industrial Products Division
Famous Players Canadian Corporation, Ltd.
Field Emission Corporation
Filmline Corporation
Dr.-Ing. Frank Früngel GmbH
GPL Division of General Precision, Inc.
General Electric Company
General Film Laboratories
W. J. German, Inc.
The Gevaert Company of America, Inc.
Guffanti Film Laboratories, Inc.
Frank Herrnfeld Engineering Corp.
Hi-Speed Equipment Incorporated
Hollywood Film Company
Hollywood Film Enterprises, Inc.
Houston Fearless Company
Philip A. Hunt Company
Hunt's Theatres
Hurletron Incorporated
JM Developments, Inc.
The Jam Handy Organization, Inc.
Jamieson Film Co.
The Kalart Company Inc.
  Victor Animatograph Corporation
Keitz & Herndon, Incorporated
KIN-O-LUX, Inc.
Kollmorgen Optical Corporation
Labcraft International Corporation
Laboratoires Cinématographiques C.T.M.
LAB-TV
Robert Lawrence Productions, Inc.
Lipsner-Smith Corporation
Lorraine Arc Carbons,
  Division of Carbons, Inc.
M.G.M. Laboratories, Inc.
McCurdy Radio Industries, Ltd.
Mecca Film Laboratories Corporation
D. B. Milliken Company
Minnesota Mining & Manufacturing Co.
Mitchell Camera Corporation
Mole-Richardson Co.
Monaco Laboratories
Monteleoni, Inc.
Motion Picture Association of America, Inc.
  Allied Artists Pictures Corporation
  Buena Vista Film Distribution Company, Inc.
  Columbia Pictures Corporation
  Metro-Goldwyn-Mayer, Inc.
  Paramount Pictures Corporation
  Twentieth Century-Fox Film Corp.
  United Artists Corporation
  Universal Pictures Company, Inc.
  Warner Bros. Pictures, Inc.
Motion Picture Enterprises, Inc.
Motion Picture Laboratories, Inc.
Motion Picture Printing Equipment Co.
Movielab Film Laboratories, Inc.
Moviola Manufacturing Co.
National Carbon Company, Division of Union Carbide Corporation
National Screen Service Corporation
National Theatre Supply Company
Neumade Products Corporation
W. A. Palmer Films, Inc.
Pan-American Films
Panavision Incorporated
Pathé Laboratories, Inc.
Pathe-DeLuxe of Canada, Ltd.
Peerless Laboratories of Canada, Ltd.
Photo-Animation, Inc.
Photo-Sonics, Inc.
Pittsburgh Motion Picture Lab
Precision Laboratories
  (Division of Precision Cine Equipment Corporation)
Prestoseal Mfg. Corp.
Producers Service Company,
  Division of Boothe Leasing Corp.
RCA Victor Company, Ltd.
Radio Corporation of America
  National Broadcasting Company
  Broadcast and Television Equipment Division
Rank Precision Industries Ltd.
  G. B-Kalee Division
Rapid Film Technique, Inc.
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
RIVA-Munich
Charles Ross Inc.
Russell-Barton Film Company
L. B. Russell Chemicals, Inc.
Ryder Sound Services, Inc.
Bruce J. Scrievers, Consulting Engineer
Scripts By Oeveste Granducci, Inc.
Smith, Kline & French Laboratories
Snazelle Productions, Inc.
Southwest Film Laboratory, Inc.
The Strong Electric Company
Sylvania Electric Products, Inc.
Technicolor Corporation
TELIC, Incorporated
Titra Film Laboratories, Inc.
Traid Corporation
Trans-Canada Films Ltd.
Van Praag Productions
Westinghouse Electric Corporation
Westrex Corporation
Wilding Inc.
Wollensak Optical Company

The Society invites applications for Sustaining Membership from other interested companies. Information may be obtained from the Chairman of the Sustaining Membership Committee, Ethan M. Stifle, Eastman Kodak Co., Room 626, 342 Madison Ave., New York 17, N.Y.